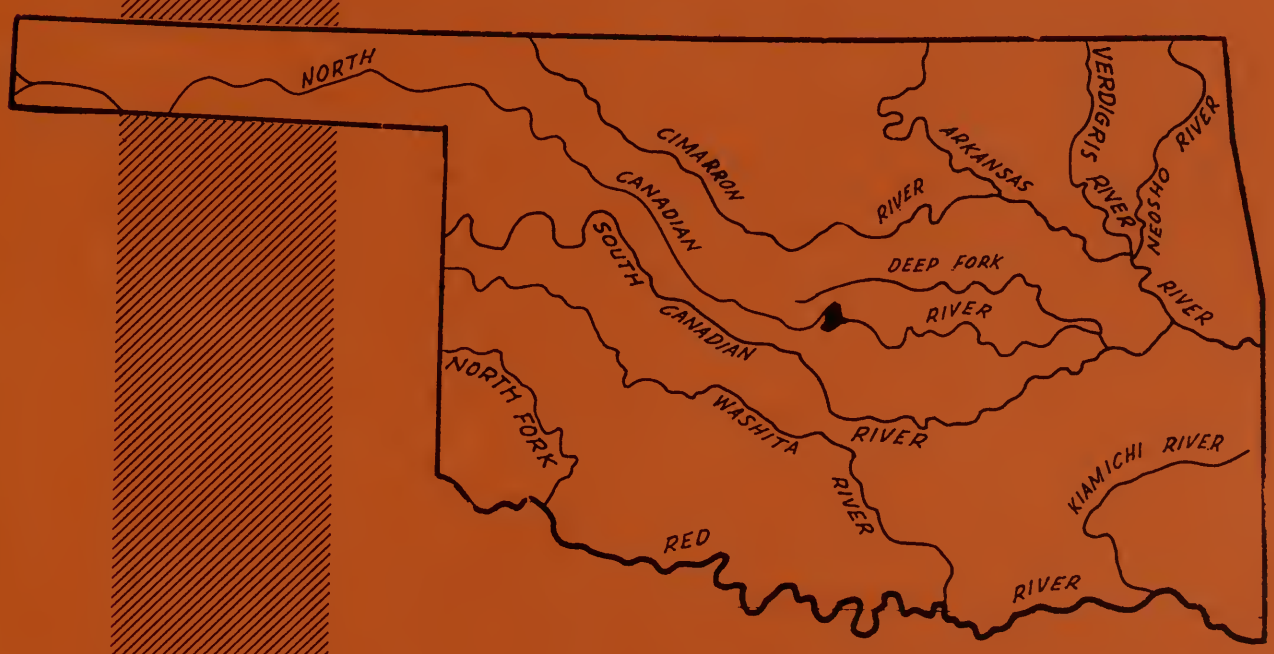
Mr Rothberg

WORK PLAN

FOR WATERSHED PROTECTION, FLOOD PREVENTION
AND RECREATIONAL DEVELOPMENT

FOUR MILE CREEK WATERSHED

CANADIAN COUNTY, OKLAHOMA



OKLAHOMA

December
1963

4-18622 2-64

WATERSHED WORK PLAN AGRE

SUMMARY OF PLAN
General Summary
Land Treatment Measure
Structural Measures
Damages and Benefits
Provisions for Financi
Share of Installatio
Operation and Maintena

DESCRIPTION OF THE WATER
Physical Data
Economic Data
Land Treatment Data

WATERSHED PROBLEMS
Floodwater Damage
Erosion Damage
Sediment Damage
Problems Relating to Wa

PROJECTS OF OTHER AGENCIE

BASIS FOR PROJECT FORMULATION 9

WORKS OF IMPROVEMENT TO BE INSTALLED 9
Land Treatment Measures 9
Structural Measures 11

EXPLANATION OF INSTALLATION COSTS 13
Schedule of Obligations 15

EFFECTS OF WORKS OF IMPROVEMENT 16

PROJECT BENEFITS 18

COMPARISON OF BENEFITS AND COSTS 19

PROJECT INSTALLATION 19

FINANCING PROJECT INSTALLATION 21

PROVISIONS FOR OPERATION AND MAINTENANCE 21
Land Treatment Measures 21
Structural Measures 22

TABLES
Table 1 - Estimated Project Installation Cost 24
Table 1A - Status of Watershed Works of Improvement 25
Table 2 - Estimated Structure Cost Distribution 26
Table 3 - Structure Data - Multiple-Purpose Structure 27
Table 3A - Structure Data - Grade Stabilization Structure 28
Table 3B - Structure Data - Channels 29
Table 4 - Annual Cost 30
Table 5 - Estimated Average Annual Flood Damage Reduction Benefits 31
Table 6 - Comparison of Benefits and Costs for Structural Measures 32

Page

AND ANALYSES 33
itions and Land Use 33
jectives 33
ment Measures 33
Measures 34
Investigations 35
d Hydrologic Investigations 37
Operation 39
n Investigations 39
ability Studies 40
ource Studies 40
estigations 41
estigations 41
of Evaluation Reaches 41
ion of Nonagricultural Damages 41
ion of Agricultural Damages 42
ion of Benefits 42
Benefits 43
Benefits 43
of Land and Easements Value 44
Methodology 44
Basic Recreational Facilities 45

FIGURES
Figure 1 - Section of a Typical Multiple-Purpose Structure With Recreation Storage 46
Figure 2 - Storage Data Recreation Reservoir, Site No. 1 47
Figure 3 - Urban Benefit Area 48
Figure 4 - Reservoir Operation Study Effect of Evaporation on Recreation Storage, Site No. 1 49
Figure 5 - Problem Location Map 50
Figure 6 - Recreational Development, Site No. 1 51
Figure 7 - Project Map 52

4-18622 2-64

WATERSHED WORK PLAN AGREEMENT

between the

East Canadian County Soil and Water Conservation District
Local Organization

Central North Canadian River Soil and Water Conservation District
Local Organization

City of El Reno
Local Organization

State of **Oklahoma**
(hereinafter referred to as the Sponsoring Local Organization)

and the

Soil Conservation Service
United States Department of Agriculture
(hereinafter referred to as the Service)

Whereas, application has heretofore been made to the Secretary of Agriculture by the Sponsoring Local Organization for assistance in preparing a plan for works of improvement for the **Four Mile Creek** Watershed, State of **Oklahoma** under the authority of the Watershed Protection and Flood Prevention Act (Public Law 566, 83d Congress; 68 Stat. 666), as amended; and

Whereas, the responsibility for administration of the Watershed Protection and Flood Prevention Act, as amended, has been assigned by the Secretary of Agriculture to the Service; and

Whereas, there has been developed through the cooperative efforts of the Sponsoring Local Organization and the Service a mutually satisfactory plan for works of improvement for the **Four Mile Creek** Watershed, State of **Oklahoma**, hereinafter referred to as the watershed work plan, which plan is annexed to and made a part of this agreement;

USDA-SCS-FORT WORTH, TEX. 1959
4-18622 2-64

4-62 4-L-16578-1

Now, therefore, in view of the foregoing considerations, the Sponsoring Local Organization and the Secretary of Agriculture, through the Service, hereby agree on the watershed work plan, and further agree that the works of improvement as set forth in said plan can be installed in about 5 years.

It is mutually agreed that in installing and operating and maintaining the works of improvement substantially in accordance with the terms, conditions, and stipulations provided for in the watershed work plan:

1. The Sponsoring Local Organization will acquire such land, easements or rights-of-way as will be needed in connection with the works of improvement. (Estimated Cost $ 450,500). The percentages of this cost to be borne by the Sponsoring Local Organization and the Service are as follows:

Works of Improvement	Sponsoring Local Organizations (percent)	Service (percent)	Estimated Land, Easements, and Rights-of-Way Cost (dollars)
Multiple-Purpose Structure No. 1 and Basic Recreational Facilities			
Payments to landowners and cost of relocation of improvements for land purchased in and adjacent to the reservoir (470 ac.)	50	50	235,000
Perpetual Easements (202 ac.)	100	0	30,000
Legal Fees, Surveys & Other Costs	100	0	6,000
Channel Improvement	100	0	128,000

2. The Sponsoring Local Organization will acquire or provide assurance that landowners or water users have acquired such water rights pursuant to State law as may be needed in the installation and operation of the works of improvement.

3. The percentages of construction costs of structural measures to be paid by the Sponsoring Local Organization and by the Service are as follows:

Works of Improvement	Sponsoring Local Organization (percent)	Service (percent)	Estimated Construction Cost (dollars)
Multiple-Purpose Structure No. 1	8.07	91.93	260,000
Minimum Basic Recreational Facilities	50	50	60,000
Channel Improvement	0	100	198,400
Grade Stabilization Structure No. 101	0	100	35,000

4. The percentages of the cost for installation services to be borne by the Sponsoring Local Organization and the Service are as follows:

Works of Improvement	Sponsoring Local Organization (percent)	Service (percent)	Estimated Installation Service Cost (dollars)
Multiple-Purpose Structure No. 1	0	100	61,500
Basic Recreation Facilities	50	50	5,750
Channel Improvement	0	100	56,045
Grade Stabilization No. 101	0	100	9,400

4a. **The sponsoring local organizations agree that all land on which Federal assistance is provided will not be sold or otherwise disposed of for the evaluated life of the project except to a public agency which will continue to maintain and operate the recreational development in accordance with the operation and maintenance agreement.**

5. The Sponsoring Local Organization will bear the costs of administering contracts. (Estimated cost $ 3,000 .)

6. The Sponsoring Local Organization will obtain agreements from owners of not less than 50% of the land above each reservoir and floodwater retarding structure that they will carry out conservation farm or ranch plans on their land.

7. The Sponsoring Local Organization will provide assistance to landowners and operators to assure the installation of the land treatment measures shown in the watershed work plan.

8. The Sponsoring Local Organization will encourage landowners and operators to operate and maintain the land treatment measures for the protection and improvement of the watershed.

9. The Sponsoring Local Organization will be responsible for the operation and maintenance of the structural works of improvement by actually performing the work or arranging for such work in accordance with agreements to be entered into prior to issuing invitations to bid for construction work.

10. The costs shown in this agreement represent preliminary estimates. In finally determining the costs to be borne by the parties hereto, the actual costs incurred in the installation of works of improvement will be used.

11. This agreement does not constitute a financial document to serve as a basis for the obligation of Federal funds, and financial and other assistance to be furnished by the Service in carrying out the watershed work plan is contingent on the appropriation of funds for this purpose.

    Where there is a Federal contribution to the construction cost of works of improvement, a separate agreement in connection with each construction contract will be entered into between the Service and the Sponsoring Local Organization prior to the issuance of the invitation to bid. Such agreement will set forth in detail the financial and working arrangements and other conditions that are applicable to the specific works of improvement.

12. The watershed work plan may be amended or revised, and this agreement may be modified or terminated, only by mutual agreement of the parties hereto.

13. No member of or delegate to Congress, or resident commissioner, shall be admitted to any share or part of this agreement, or to any benefit that may arise therefrom; but this provision shall not be construed to extend to this agreement if made with a corporation for its general benefit.

East Canadian County Soil and Water Conservation District
Local Organization

By Walter C. Bowers

Title Chairman

Date 3-11-64

The signing of this agreement was authorized by a resolution of the governing body of the **East Canadian County Soil and Water Conservation District**
Local Organization

adopted at a meeting held on March 5, 1964

Vesta V. Fuchs
(Secretary, Local Organization)

Date 3-11-64

Central North Canadian River Soil and Water Conservation District
Local Organization

By Harvey Base

Title Chairman

Date March 11, 1964

The signing of this agreement was authorized by a resolution of the governing body of the **Central North Canadian River Soil and Water Conservation District**
Local Organization

adopted at a meeting held on 3-11-64

Harvey Glover
(Secretary, Local Organization)

Date Okar. 11-64

City of El Reno
Local Organization

By Wm. L. Marshall

Title Mayor

Date March 11, 1964

The signing of this agreement was authorized by a resolution of the governing body of the **City of El Reno**
Local Organization

adopted at a meeting held on March 11, 1964

Ermal Blair, City Clerk
(Secretary, Local Organization)

Date March 11, 1964

Soil Conservation Service
United States Department of Agriculture

By _____

Date _____

WORK PLAN

FOR

WATERSHED PROTECTION, FLOOD PREVENTION AND RECREATIONAL DEVELOPMENT

FOUR MILE CREEK WATERSHED
Canadian County, Oklahoma

Prepared Under the Authority of the Watershed Protection and Flood Prevention Act. (Public Law 566, 83rd Congress; 68 Stat. 666), as amended.

Prepared By:

East Canadian County Soil and Water Conservation District
(Sponsor)

Central North Canadian River Soil and Water Conservation District
(Sponsor)

City of El Reno, Oklahoma
(Sponsor)

With Assistance By:

U. S. Department of Agriculture
Soil Conservation Service

December 1963

WATERSHED WORK PLAN

FOUR MILE CREEK WATERSHED
Canadian County, Oklahoma
December 1963

SUMMARY OF PLAN

General Summary

The work plan for watershed protection, flood prevention and recreational development for the Four Mile Creek watershed, Oklahoma, was prepared by the East Canadian County and the Central North Canadian River Soil and Water Conservation Districts and the City of El Reno as the sponsoring local organizations. Technical assistance was provided by the Soil Conservation Service of the U. S. Department of Agriculture.

The watershed covers an area of 24.0 square miles or 15,360 acres. Of this area 3,053 acres are flood plain. Approximately 64.7 percent of the watershed is cropland; 14.9 percent is native rangeland; 3.1 percent is tame pasture and 17.3 percent is in miscellaneous uses, including 310 acres of Federally-owned land.

The flood plain of Four Mile Creek is subject to frequent and severe flooding. Floods inundating approximately 50 percent or more of the flood plain occur on the average of almost one every two years.

The installation and operation of this project will protect the urban area in Four Mile Creek and unnamed tributary flood plain from a 12-hour, 100-year frequency flood. The agricultural area of Four Mile Creek flood plain will be protected from a 12-hour, 10-year frequency flood. Flooding from the unnamed tributary only will be reduced approximately 70 percent in the agricultural area of its flood plain. The reduction of flooding will make it possible to more fully utilize the entire flood plain.

The work plan proposes a 5-year period for installing the needed works of improvement at a total estimated cost of $1,139,079. The share of this cost to be borne by other than Public Law 566 funds will be $385,341, and the Public Law 566 share will be $753,738.

Land Treatment Measures

Land treatment measures will be established by the landowners and operators of watershed lands during the 5-year project installation period. Emphasis will be placed on accelerating the establishment of those land treatment measures which will have a measurable effect on reduction of floodwater and sediment damages and the cost of providing sediment storage capacity in floodwater retarding structures. They comprise, primarily, measures required to establish good land cover and soil conditions which will decrease erosion damage and sediment yields from cultivated fields and pasture.

The cost for land treatment is estimated to be $50,984, of which $46,984 will be borne by other than Public Law 566 funds. The Public Law 566 share, which consists entirely of accelerated technical assistance, is $4,000.

Structural Measures

The structural measures included in the plan consist of 1 multiple-purpose structure (recreational water and flood prevention storage), recreational facilities and 4.80 miles of stream channel improvement, including 1 grade stabilization structure. The multiple-purpose structure will have an aggregate capacity of 4,392 acre-feet for floodwater detention, recreational water supply and sediment storage. The structural measures will provide flood protection to 3,053 acres of flood plain land and will cost $1,088,095, of which the local share is $338,357, and the Public Law 566 share is $749,738. The local share of the cost of structural measures includes construction cost of the multiple-purpose structure ($20,982), and recreational facilities ($30,000), installation services of recreational facilities ($2,875), legal fees ($6,000), land, easements and rights-of-way ($275,500), and administration of contracts ($3,000).

Damages and Benefits

The reduction in floodwater, sediment, flood plain erosion and indirect damages will directly benefit approximately 15 landowners with agricultural land in the flood plain in addition to the owners and occupants of about 500 residential and business units.

The estimated average annual floodwater, sediment, flood plain erosion and indirect damages without the project total $65,179, at long-term price levels.

The multiple-purpose development will provide an average of $21,000 annually in benefits from recreation.

Processors of agricultural commodities and other business establishments in the area will benefit from the project.

The average annual primary benefits accruing to structural measures are estimated to be $97,083, distributed as follows:

Floodwater damage reduction	$48,904
Sediment (overbank deposition) reduction	177
Erosion (flood plain scour) damage reduction	374
Indirect damage reduction	7,996
Urban enhancement	18,632
Recreation	21,000
Total	$97,083

Secondary benefits of $8,908 annually will result from the project.

The ratio of average annual benefits, including secondary benefits, accruing to structural measures ($105,991) to the average annual cost of structural measures ($57,708) is 1.8 to 1.

The conservation benefits from land treatment measures were not used for project justification since experience has shown that these soil and water conservation measures produce benefits in excess of their costs. However, $1,395 of annual flood reduction benefits can be attributed to these measures.

Provisions for Financing the Local Share of Installation Costs

The city of El Reno will contract for the construction of the multiple-purpose structure, the stream channel improvement, including a grade stabilization structure, and the recreational facilities.

With assistance from the soil and water conservation districts, the city of El Reno will obtain easements and will provide the local share of installation cost for the structural measures. Funds will be raised as needed by bond sales. The estimated local cost for the installation of structural measures is $338,357.

Operation and Maintenance

Land treatment measures will be maintained by the landowners or operators of the farms on which the measures are installed, under agreements with the East Canadian County and Central North Canadian River Soil and Water Conservation Districts. The multiple-purpose structure, recreational facilities and the stream channel improvement will be operated and maintained by the city of El Reno. Bond sales and other city funds will be supplemented by fees for use of the recreational facilities. The estimated average cost of operation and maintenance of structural measures is $19,900, based on long-term price levels, of which $11,600 are for operation, maintenance and replacement of basic recreational facilities over the life of the project.

DESCRIPTION OF THE WATERSHED

Physical Data

Four Mile Creek watershed, with an area of 15,360 acres (24.0 square miles), is located in central Oklahoma. Four Mile Creek heads approximately 5 miles southwest of El Reno, in Canadian County, and flows in a general northeasterly direction through the northern section of the urban area of El Reno to its confluence with the North Canadian River approximately 2 miles northeast of the city. The distance of overland flow from head to mouth is approximately 8 miles. The main stem of Four Mile Creek is joined by two unnamed tributaries within the urban area of El Reno. An unnamed tributary, draining the eastern portion of the watershed, flows northeastward to the North Canadian River sharing a common flood plain with Six Mile Creek.

The U. S. Southwestern Reformatory is located partially in the watershed. There are 310 acres of Federally-owned land within the watershed. This land is under the jurisdiction of the Bureau of Prisons; however, prison installations are outside of the watershed.

There are two distinct topographic areas in the watershed. There is an almost flat alluvial terrace bordering the North Canadian River and covering about 5,000 acres in the lower part of the watershed. The remainder of the area is gently rolling upland.

The watershed lies within the Redbed Plains physiographic area and the Reddish Prairies land resource area. Geologic formations cropping out are, in descending order, the Dog Creek shale, the Blaine formation, and the Flowerpot shale, all of the Enid group of Permian age. The wide alluvial bench in the lower part of the watershed is of Pleistocene and Recent age. There are also remnants of a high terrace which are probably Pleistocene in age.

Soils on the upland have developed largely on shale and are generally medium textured, slowly permeable and productive. Shallow and very shallow soils occur in some areas. Alluvial soils are deep, medium textured, moderately to slowly permeable and highly productive.

The land use in the watershed is:

Land Use	Acres	Percent
Cropland	9,930	64.7
Rangeland	2,300	14.9
Tame Pasture	475	3.1
Miscellaneous 1/	2,655	17.3

1/ Includes 2,520 acres of urban area, including 310 acres of Federally-owned land, and 135 acres of highways, roads, railroads, etc.

Water for livestock and rural domestic use is supplied from farm ponds and wells. These sources furnish sufficient water during years of normal rainfall but are not dependable during extended periods of drouth. The city of El Reno obtains water from a series of wells in the alluvium of the North Canadian River. The wells are outside the watershed boundary.

The watershed lies in the moist subhumid climatic zone. The average frost-free period of 209 days extends from March 23 through October 30. Mean temperatures range from 86 degrees Fahrenheit in summer to 46 degrees in winter. The mean annual temperature is 61.1 degrees Fahrenheit. The extreme recorded temperatures were 10 degrees below zero and 111 above zero.

During the period 1931 through 1962 the average annual rainfall recorded at the El Reno gage was 28.71 inches, ranging from a maximum of 45.14 inches in 1959 to a minimum of 14.60 inches in 1954.

Forty-one percent of the annual rainfall occurs in the months of April, May and June; 27 percent in July, August and September; 18 percent in October, November and March and the remaining 14 percent is evenly distributed through the other 3 months. Frontal storms frequently occur in the spring and fall, less frequently in the summer and rarely in the winter months. The most recent major flood (with a two percent chance of occurrence) occurred in September 1961 and inundated approximately 90 percent of the flood plain.

Economic Data

All of the Four Mile Creek watershed is within the city limits of El Reno, the major city and county seat of Canadian County, Oklahoma. However, the urban and business district of the city covers approximately 4 square miles, all of which are within the watershed boundary. The watershed is located in the central part of Canadian County, 27 miles west of downtown Oklahoma City. Oklahoma City's major airport, Will Rogers Field, is located approximately 25 miles southeast of El Reno. Tinker Air Force Base is located approximately 35 miles southeast of El Reno.

El Reno is on U. S. Highway 66, 81 and 270. Interstate Highway 40 will pass one mile south of the business area and less than one-half mile south of the present U. S. Highway 66 where it intersects U. S. Highway 81. A major north-south line of the Chicago, Rock Island and Pacific Railroad extending from Chicago to Houston, intersects at El Reno with a major east-west line of the Rock Island extending from Memphis, Tennessee to Tucumcari, New Mexico. All of these transportation routes cross Four Mile Creek and are affected by its flood waters.

El Reno is an important agricultural, governmental, trade and transportation center for the watershed and the surrounding area. The Rock Island Railroad

district and division headquarters, a Federal reformatory, two large flour mills and extensive grain storage facilities are located in the city. As a major highway junction, El Reno has also become a center for travel-related industries, such as motels and gasoline service stations.

The economy of El Reno has been adversely affected by the loss of population in Canadian County from a reduction in personnel employed by the railroad and by the movement of three manufacturers to other areas. Although the population of Canadian County has dropped from 28,115 in 1930 to 24,727 in 1960, the population of El Reno has increased from 9,384 to 11,015 in the same period of time. It is expected that the population of Canadian County will double by 1985 due to the encroachment of the Oklahoma City metropolitan area.

In relation to total value of farm products, Canadian County ranks sixth highest in Oklahoma. Wheat and other small grains are grown as cash crops and as supplemental feed and pasture crops for livestock and poultry enterprises.

Agricultural statistics reveal that wheat is grown on 133,000 of the 244,000 acres of land cultivated in the county.

The average size farm in the county is 350 acres. Land and buildings have an average value per farm of $57,000. The average farm size has increased from 250 acres in 1949 to 350 acres in 1960, while the value of land and building increased from $26,000 to $48,000. Cultivated crops produce 45 percent of the farm income and livestock produces 55 percent of the total farm income in the county. Beef cattle produce 81 percent of the total income from livestock and poultry.

Land Treatment Data

The watershed is served by Soil Conservation Service work units located in El Reno and Geary. These work units provide technical assistance to the soil and water conservation districts and have assisted farmers and ranchers in the preparation of basic soil and water conservation plans on 6,750 acres (approximately 65 percent of the total area of 12,705 acres in agricultural use). About 65 percent of the planned practices have been applied (table 1A).

WATERSHED PROBLEMS

Floodwater Damage

There are 3,053 acres of flood plain in the watershed that would be inundated by the surface runoff from a 12-hour, 100-year frequency storm.

A study of the flood plain revealed that 872 acres are associated with Four Mile Creek proper, of which 166 acres are urban and 706 acres are used for agricultural purposes. Of the 706 acres used for agriculture, 40 acres are

common to the North Canadian River. Another 2,181 acres are associated with an unnamed tributary of which 218 acres are urban and 1,963 acres are used for agricultural purposes. Of the 1,963 acres used for agriculture, 1,246 acres have a common flood plain with Six Mile Creek and the North Canadian River. There are 734 acres common to Six Mile Creek and the unnamed tributary and another 512 acres are common to Six Mile Creek, the North Canadian River and the unnamed tributary. Flooding is frequent on this 1,246 acres of common flood plain but only a small portion of the flood damage results from the run-off from the drainage area of the unnamed tributary since this drainage area represents a relatively small portion of the total drainage area contributing to the flooding of this common flood plain area.

Flooding occurs frequently in the watershed and causes moderate to severe damages to business establishments, industries, residential areas, agricultural lands, transportation facilities and other publicly and privately-owned utilities. One of the three manufacturing concerns moving from El Reno moved because of severe and frequent flooding of manufacturing facilities. Floods inundating approximately 50 percent or more of the flood plain occurred in May 1949, May 1951, November 1953, October 1959, October 1960, and September 1961. Flooding is most common during the spring season. Some attempts have been made by local interest to clean, straighten and enlarge the Four Mile Creek stream channel, but these efforts have had little effect on the reduction of flood damage from major storms.

It is estimated that the flood of 1953, which is one of the larger floods in the memory of local residents, flooded 353 acres of the urban area of El Reno. There were approximately 475 homes and 25 businesses affected by this flood besides railroad property, city streets, a sewage disposal plant, two city parks, public utilities and other miscellaneous items. It is estimated that the direct and indirect primary damages done by this flood in the urban area, plus damages to crops and pastures, were $260,000 computed at present day prices.

Based on the frequency method of computing annual floodwater damage, with the 1953 flood assigned a frequency of once in 60 years, the average annual damages are estimated to be $55,387, and includes $12,971 to crop and pasture, $9,150 to utilities, $22,499 to residential, $10,767 to business and industry. Indirect damages, such as interrupted transportation facilities and reduced sales, average $8,759 annually.

Erosion Damage

Severe flooding has caused scour damage on 134 acres of agricultural flood plain land. Damages range from 10 to 40 percent in terms of reduced productive capacity. Presently there are 75 acres damaged 10 percent, 44 acres damaged 20 percent and 15 acres damaged 40 percent. Flood plain scour is estimated to cause an average of $806 in damages annually.

Sheet erosion on cultivated land is the major source of sediment from uplands. About 65 percent of the watershed is in cultivation. Erosion caused by burning of tree and grass cover has not been a major problem in the watershed. Educational programs emphasizing the detrimental effects of burning have been effective in preventing fires. These programs have been

supported by the schools, the city, the Extension Service, the Oklahoma State Forestry Division and the local soil and water conservation district.

Sediment Damage

Damage by sediment deposition on the agricultural flood plain of Four Mile Creek has been slight. A total of 66 acres, about 2.2 percent of the total flood plain, has been damaged by deposits of silt ranging in depth from 12 inches to 2 feet. Damage from these deposits did not exceed 10 percent in terms of reduced productive capacity. Damage from overbank deposition under present conditions amounts to $227 annually. Sediment deposition on roads and bridges has been moderate but was not evaluated separately from floodwater damages.

Problems Relating to Water Management

The city has ample municipal water supply for the foreseeable future from existing wells along the North Canadian River. The area from which water is being drawn could be extended by additional wells, should the need develop.

Recreational opportunities are available at Fort Cobb Reservoir, 45 miles to the southwest, and Canton Reservoir, 60 miles northwest. Some recreational opportunities are offered by the reservoirs in Oklahoma City, a distance of 25 miles, however, this is limited due to the demand in the metropolitan area. U. S. Census reports show the total population for the 10 counties that fall within a 50-mile radius of the watershed has increased from 509,856 in 1940 to 685,433 in 1960, an increase of 17 percent.

Additional recreational facilities are needed that would furnish water based recreation such as fishing, boating, swimming, skiing, hiking, riding, picnicking, camping, etc. The local sponsors desired to include recreational water storage in the structure, thus making recreational development a project purpose.

Drainage needs can be met by on-farm drainage systems for which suitable outlets are available.

Water supply storage for irrigational purposes is not feasible.

PROJECTS OF OTHER AGENCIES

There are no projects of other agencies, county, State or Federal, now proposed or constructed, which will affect or be affected by the works of improvement included in the plan.

BASIS FOR PROJECT FORMULATION

Flood problems in agricultural and urban areas, water management needs and watershed protection needs were reviewed with local sponsors and other interested groups, including representatives from the city of El Reno, county, State and Federal agencies. It was determined in preliminary investigations that a high level of control would be needed to provide the desired reduction in flood damages. Losses in the urban area from flooding have been extremely high.

It was agreed by the sponsors and the Service to plan a project that would:

1. Include land treatment measures, based on current needs, which can be applied during the project installation period and which contribute directly to watershed protection and flood prevention.

2. Reduce average annual agricultural and rural nonagricultural floodwater damages approximately 70 to 80 percent in the agricultural flood plain of Four Mile Creek and the unnamed tributary of Six Mile Creek where flooding is not influenced by Six Mile Creek and the North Canadian River.

3. Furnish protection to the urban area of El Reno from the runoff expected from a storm that will occur on an average of once in 100 years.

4. Provide the needed protection by floodwater retarding structures insofar as possible.

5. Improve the Four Mile Creek stream channel through the urban and agricultural area as needed to attain the project objectives.

6. Provide a recreational development for the community.

Alternate systems of structural measures were studied. The most feasible method of adequately solving the watershed problems and meeting the project objectives was determined to be the application of land treatment measures and construction of one multiple-purpose structure with recreational facilities and channel improvement through the urban area and downstream agricultural area.

WORKS OF IMPROVEMENT TO BE INSTALLED

Land Treatment Measures

An effective conservation program based upon the use of each acre of agricultural land within its capabilities and its treatment in accordance with its needs, such as is now being carried out by the East Canadian County and the Central North Canadian River Soil and Water Conservation Districts,

is essential for a sound and continuing watershed protection program. The extent of needed land treatment measures which have been applied to date within the watershed represents an expenditure by landowners and operators of $106,372 (table 1A).

Approximately 4,350 acres of the 9,307 acres of upland in the watershed lie above the planned multiple-purpose structure. Land treatment is especially important for protection of these watershed lands to support and protect the structural measures. Land treatment on the proposed channel, consisting of vegetation of spoil areas and channel side slopes, will be needed to reduce erosion and resulting maintenance problems. The remaining upland has no structural control and the establishment and maintenance of land treatment constitute the only planned measures.

Land treatment measures on the 2,669 acres of agricultural flood plain land and adjoining 2,562 acres of agricultural bottom land are important in reducing floodwater and scour damages on the flood plain and in maintaining high levels of agricultural productivity.

Emphasis will be placed on accelerating the establishment of those land treatment measures which will have a measurable effect on reduction of floodwater and sediment damages and the cost of providing sediment storage capacity in the floodwater retarding structure and reduction in cost of maintenance of channel improvement.

Table 1 includes estimates of the acres to be treated in each major land use and cost of land treatment important for watershed protection which will be established by the landowners and operators of watershed lands during the installation period. They comprise, primarily, measures required to establish good land cover and soil conditions which will decrease erosion damage and sediment yields from cultivated fields and pastures. Cropland treatment measures include: cover cropping; conservation cropping systems; and improved tillage to attain crop residue use for soil protection and conditioning. Pasture and rangeland treatment measures include: construction of farm ponds to provide sufficient numbers and locations of watering places to protect vegetative cover, or to make practicable the utilization of land for vegetative cover; pasture planting and range seeding to establish good cover on lands formerly tilled and on range with poor cover; and proper use of pasture and range cover. Practices that will contribute to the expansion and perpetuation of wildlife resources will be installed along with protection from fire and livestock. These practices will include wildlife development of ponds, odd upland areas and wet lands.

In addition to the soil improvement and cover measures, land treatment includes contour farming, terracing, diversion construction and the waterway development to serve these measures. Terracing and contour farming have a measurable effect on reducing peak discharge by slowing the runoff from fields. These measures also augment the soil improvement and cover measures in reducing erosion damage and sediment yield.

Structural Measures

The structural measures consist of one multiple-purpose structure (floodwater detention and recreation water supply storage), basic facilities for a recreational development and 4.80 miles of stream channel improvement, including a grade stabilization structure. These measures are required to supplement land treatment measures in meeting project objectives. The drainage area of the proposed multiple-purpose structure is 4,500 acres. This comprises 80.8 percent of the drainage area of Four Mile Creek above the urban area of El Reno and 29.3 percent of the total area of the watershed.

All applicable state water laws will be complied with in the design and construction of the structure. The design of the multiple-purpose structure will conform with Oklahoma Water Resources Board Resolution dated January 10, 1961.

Figure 1 shows a typical section of a multiple-purpose structure. The locations of the structural measures are shown on the Project Map, figure 7.

Floodwater detention capacity was planned in the structure to temporarily detain the runoff from a 100-year frequency storm. The runoff from this storm was determined by a regional analysis of stream gage records in an area of similar geologic formation, topography and average annual rainfall. There is sufficient capacity in the structure to make the use of a vegetated emergency spillway possible, thereby effecting a substantial reduction in cost over concrete or similar-type spillways.

The total floodwater detention capacity in the structure is 2,865 acre-feet. The amount of runoff controlled is 7.64 inches. There will be 818 acre-feet of capacity in the structure for sediment storage and 709 acre-feet of water supply for recreation. The aggregate capacity is 4,392 acre-feet for all purposes.

Approximately 48 acres of bottom land and 38 acres of upland will be in the sediment pool area of the structure. In addition to the sediment pool, the recreation pool will inundate 33 acres of bottom land and 51 acres of upland. An additional 60 acres of bottom land and 175 acres of upland will be inundated temporarily by the detention pool.

A small portion of the multiple-purpose structure and recreation facilities is located on Federal land under the jurisdiction of the Bureau of Prisons. The sponsoring local organization will enter into a written cooperative agreement with the Bureau of Prisons to provide for land, easements, and rights-of-way for works of improvement located on Federal land. Close working relations have been maintained between the sponsors and the local representatives of the Bureau of Prisons and it is indicated that the installation of works of improvement proposed on Federal land will be

acceptable. Since only a small portion of the multiple-purpose structure and basic recreation facilities is on Federally-owned land, these measures were treated in table 1 as though they were located entirely on non-Federal land.

The total area needed for the multiple-purpose structure, including recreation is 775 acres, 610 acres of which are within the maximum flow line, 133 acres for recreational use outside the maximum flow line and 32 acres needed for dam and emergency spillway. The surface area of the recreation pool is 170 acres. The total area to be used for recreation is 573 acres, including the recreation pool. Basic facilities will be installed for recreational use. These facilities include access roads, parking areas, boat launching ramps, water supply, sanitary facilities, a beach development and picnicking and camping areas. A schedule of the proposed facilities is shown in table A. Figure 6 shows the location of these facilities.

Stream channel improvement will be installed to supplement the multiple-purpose structure to provide the desired level of protection. The alignment of the present channel will generally be used. A grade stabilization structure (concrete drop) will be placed in the main channel approximately 2,100 feet upstream from the North Canadian River. Grade stabilization structures (pipe drops) will be installed in side drains and road ditches for the protection of the main channel against bank erosion. Suitable vegetation to reduce erosion will be used in all channels.

The capacity of the channel above station 215+00 was designed to contain the runoff from a 12-hour, 100-year frequency storm from the uncontrolled area, plus the release flow from the structure. In the transition reach between stations 215+00 to 225+00 the capacity of the channel was designed to decrease from that needed to contain the 100-year frequency storm runoff to 10-year frequency storm runoff. The portion of the channel below station 225+00 was designed to carry the runoff from a 12-hour 10-year frequency storm from the uncontrolled area, plus the release flow from the floodwater retarding structures.

Spoil from excavating and improving the stream channel will be shaped or spread adjacent to the channel. In agricultural areas where land is already cleared and is in cultivation or improved pasture, the spoil will be spread to a maximum height of 3 feet and a maximum 8 to 1 side slope. Where the area to be occupied by the spoil is still in timber, which must be cleared, the spoil will be shaped to a maximum height of 5 feet and a maximum 4 to 1 side slope. In the urban areas the spoil may be shaped for a higher fill to reduce the right-of-way needed. Spoil will be placed on one or both sides of the channel depending upon the quantity. When possible spoil will be placed on one side only in order to save right-of-way and clearing cost. Spoil will be spread only within the right-of-way and no more than 250 feet from centerline of ditch. The boundaries of the right-of-way needed for excavation and spoil spreading will be shown on the land rights map.

The location of the channel on the project map is approximate, but it will be designed and constructed within the right-of-way as shown on the land rights map.

No fences will be built within the design depth of flow of any ditch. Where fences cross channels, suitable water gates will be installed for which costs must be borne by local interests. As near as possible and practicable bridges placed across the channel will be designed with adequate capacity and general shape to effect the minimum impedance to design flows within the channel.

The total estimated cost for establishing the structural works of improvement is $1,088,095. Table 1 shows project installation cost. Table 2 shows cost distribution for each structure. Tables 3, 3A, and 3B show design data for each structure.

EXPLANATION OF INSTALLATION COSTS

Local interests will install the land treatment measures at an estimated cost of $43,384, which includes any assistance under ACP. In addition, $3,600 will be provided for technical assistance under going programs. Public Law 566 funds will provide technical assistance to accelerate the installation of land treatment measures for watershed protection and are estimated to be $4,000. The estimated total cost of planning and installing the land treatment measures is $50,984 (table 1).

Land, easements and rights-of-way for the area for recreational development and multiple-purpose structure will be cost-shared with Public Law 566 funds paying not more than 50 percent of the actual payments and local interests paying the remainder. Those areas occupied by the proposed Interstate Highway 40 will be furnished by local interests and will not be eligible for cost-sharing. Land, easements, and rights-of-way for the channel improvement will be furnished by local interests.

The cost of the multiple-purpose structure, including a recreational development, and the stream channel improvement and its appurtenances is estimated as follows:

4.80 Miles of Stream Channel Improvement and Appurtenances

The local costs are estimated to be $129,500. They consist of land, easements and rights-of-way ($73,500), relocating utilities ($20,000), roads and bridges ($34,500), and the cost of administering contracts ($1,500). The installation cost of the stream channel improvement to be borne by Public Law 566 funds totals $254,445. The construction cost ($198,400), $29,000 of which is for railroad, bridge and abutment alterations, includes engineers' estimates and a contingency allowance

of 10 percent. The engineers' estimates were based upon previous construction cost of stream channel improvement with similar construction conditions and a preliminary geological investigation.

Installation services ($56,045) includes the services of engineers, geologists and administrative personnel. The total cost of this measure is estimated to be $383,945.

A grade stabilization structure will be included in the stream channel improvement and is estimated to cost $44,700. Local part of this cost is $300 for administration of contracts. Federal cost is $44,400 ($35,000 construction cost and $9,400 installation services), a grand total cost for stream channel improvement of $428,645.

Multiple-Purpose Structure No. 1

Land needed for the reservoir and the recreational development is as follows:

Area of embankment and emergency spillway	32 acres
Area of maximum flow line of structure	610 acres
Area of minimum basic facilities (outside of maximum flow line)	133 acres
Total area needed	775 acres

Included in this area is 103 acres of Federal land which will not be included for cost sharing. The area in the development eligible for cost sharing and proposed to be purchased is 470 acres. Fee simple title of land will be acquired on this 470 acres to insure public access. Perpetual easements will be acquired on 202 acres by the local sponsors at no cost to the Federal government.

The sponsors' share of the cost of the multiple-purpose structure and recreational facilities is as follows:

Item	Percent of Total Cost	Estimated Sponsors' Cost (Dollars)
Multiple-Purpose Structure No. 1		
Construction 1/	8.07	20,982
Land, Easements and Rights-of-way to be Purchased	50.00	117,500
Perpetual Easements	100.00	30,000
Administration of Contracts and Legal Fees	100.00	6,600
Minimum Basic Facilities		
Construction	50.00	30,000
Installation Services	50.00	2,875
Administration of Contracts	100.00	600
Totals (Sponsors' cost)		208,557

1/ Fifty percent of the cost allocated to recreation water storage.

The Public Law 566 funds that will be used for the multiple-purpose structure total $386,518 and are estimated to be as follows: construction ($239,018); installation services ($61,500); and land, easements and rights-of-way($86,000). The installation cost of the minimum basic facilities to be borne by Public Law 566 funds totals $64,375 and consist of construction ($30,000), installation services ($2,875) and $31,500 land, easements and rights-of-way. The total cost of the multiple-purpose structure is estimated to be $528,500. The estimated installation cost of the basic recreation facilities is $130,950.

All the cost ($428,645) of the stream channel improvement, including a grade stabilization structure, was allocated to flood prevention.

All the cost ($130,950) of basic recreation facilities and associated land was allocated to recreation.

All the cost for land, easements and rights-of-way, including legal fees for the multiple-purpose structure, were treated as specific cost for recreation. The Use of Facilities method was used to allocate joint cost for the reservoir as follows:

	Recreation	Flood Prevention	Total
Purpose in Acre-Feet	709	3,683	4,392
Percentage for Cost-Sharing	16.14	83.86	100.0

The total cost of the multiple-purpose structure was allocated $280,898 (53.15 percent) to recreation and $247,602 (46.85 percent) to flood prevention.

The total structural measures estimated cost of $1,088,095 was allocated $411,848 to recreation and $676,247 to flood prevention. These costs will be shared $749,738 Public Law 566 funds and $338,357 from other funds.

The proposed schedule of obligations for the 5-year installation period for land treatment and structural measures shown below may be adjusted from year to year as mutually agreed to and based on appropriations and accomplishments actually made.

Schedule of Obligations

Fiscal Year	Public Law 566 Funds: Structural Measures	Public Law 566 Funds: Land Treatment Measures	Other Funds: Structural Measures	Other Funds: Land Treatment Measures	Total
	(dollars)	(dollars)	(dollars)	(dollars)	(dollars)
1965	117,500	1,000	153,500	10,000	282,000
1966	300,518	1,000	21,582	10,000	333,100
1967	32,875	900	101,645	10,000	145,420
1968	205,510	600	32,240	10,000	248,350
1969	93,335	500	29,390	6,984	130,209
Total	749,738	4,000	338,357	46,984	1,139,079

EFFECTS OF WORKS OF IMPROVEMENT

Under present conditions, a 12-hour, 100-year frequency storm will yield 4.97 inches of surface runoff. This flood would inundate 3,053 acres of flood plain, 384 acres of which are urban and 2,669 acres are agricultural land. Twelve hundred and eighty-six acres of the flood plain in the agricultural area are also affected by floodwater from Six Mile Creek and the North Canadian River.

With the installation and operation of the project the 384 acres of flood plain in the urban area will be completely protected from flooding caused by the runoff from a 12-hour, 100-year frequency storm. The 666 acres of agricultural land on Four Mile Creek proper will be protected from flooding caused by the runoff from a 12-hour, 10-year frequency storm. Forty acres of flood plain common to Four Mile Creek and the North Canadian River will not benefit appreciably from the project. Flooding will be reduced about 70 percent on 717 acres of the 1,963 acres of agricultural land that is associated with the unnamed tributary. Approximately 1,246 acres of these 1,963 acres are common to Six Mile Creek and the North Canadian River and the effect of floodwaters from these streams will virtually nullify any benefits to these acres (1,246) that could otherwise be expected from the planned works of improvement.

The installation of structural measures will result directly in the withdrawal of approximately 775 acres from crop production. Another 182 acres will be withdrawn from agricultural use, due to urban expansion that is expected to occur as a result of the project. Land use with and without the project is:

Land Use	Without Project (acres)	With Project (acres)
Crop		
Wheat	5,334	5,239
Oats	1,896	1,638
Barley and Rye	1,592	1,389
Sorghum	865	639
Legumes	243	243
Subtotal	9,930	9,148
Pasture	2,775	2,475
Miscellaneous 1/	2,655	3,737
Subtotal	5,430	6,212
Total	15,360	15,360

1/ Includes 125 acres of right-of-way for proposed Interstate Highway 40.

Gross erosion in the watershed will be reduced from 48.3 acre-feet to 37.3 acre-feet annually, through application of planned land treatment measures, a decrease of 23 percent. Sediment yield at the mouth of the watershed will be reduced from the present rate of 23.4 acre-feet to 19.8 acre-feet annually by land treatment and further reduced to 7.0 acre-feet annually by the multiple-purpose structure.

Flood plain erosion accounts for about 11 percent of the total gross erosion in the watershed. The project will eliminate erosion and overbank deposition on the flood plain of Four Mile Creek and will reduce these damages by approximately 49 percent and 80 percent respectively for the total flood plain area.

This project will directly benefit approximately 15 landowners and operators of agricultural land in the flood plain and the owners and occupants of about 500 residential, industrial and business units.

A comprehensive plan for the future development of El Reno has been prepared by a consulting firm in cooperation with members of the County Board of Commissioners, City Council members and members of the Metropolitan Area Planning Commission. This plan was developed under the assumption that flooding would be eliminated in the urban area of El Reno by the installation of a watershed protection program of land treatment measures, floodwater retarding structures and channel improvement. It is expected that under this plan the present low density use of the flood plain area of Four Mile Creek (from U. S. Highway 66 at west edge of town, northeast to U. S. Highway 81 at north edge of town) will be developed into a high density use area when the flooding conditions are remedied.

The area from U. S. Highway 81 east and south along the Rock Island tracks to Cavenaugh Street will be available for industrial development without the threat of flood damage.

Relatively undeveloped urban areas presently subject to flooding can develop with the normal growth of other urban areas. When flooding is eliminated the value of property in all of the flood plain area will approach the value of property of like quality in non-flooding areas.

Net farm income will be increased on the agricultural area of the flood plain when flood damages to crops and pastures are reduced.

Wildlife resources are limited throughout the area. The agricultural land is for the most part cultivated up to the edge of the drainageways. Trees occupy the short channel slopes at infrequent intervals. The installation of the multiple use reservoir will result in temporary loss to song and insectivorous birds but will be compensated for by the planned afforestation program and permanent water of the impoundment.

The planned channel improvement portion of the project should have no detrimental effect on the wildlife resources.

The accelerated land treatment program contemplated for the upper reaches of the watershed will be of benefit to the scanty wildlife population existing in the area. Wheat is the major crop and the stubble and waste grain is commonly turned under at once behind the combines if soil moisture conditions permit. Crop rotations associated with the usual land treatment in conservation will improve conditions for wildlife to some degree.

Opportunities for development of recreational features are excellent. The multiple-purpose structure is within an hours drive from Oklahoma City and for many residents of El Reno, it is within walking distance. Facilities planned will permit full use of the development, such as fishing, boating, skiing, picnicking, swimming and camping. Many of the recreational facilities could be used the entire year, but the most concentrated use will be during the spring and summer months. It is estimated that 5,000 people will use the recreational development annually. The peak daily use is expected to be 1,700 people.

The project will create additional employment opportunities for the local residents. The firms contracting for installation of the structural improvements will hire a large percentage of the skilled and unskilled labor from the immediate locality. The operation and maintenance of structural measures over the life of the project will also provide employment opportunities for the local residents.

Secondary benefits, including increased business activity and improved economic conditions in the surrounding communities, will result from the installation of the complete project. Economic activities will be stimulated by sales of boats, motors, fishing and camping equipment and other items associated with improved recreational opportunities. In addition, there are intangible benefits such as an increased sense of security and the opportunity to plan future developments without consideration of frequent flooding. Local secondary benefits were considered to be equal to 10 percent of the direct primary benefits.

PROJECT BENEFITS

The estimated average annual floodwater, erosion, sediment and indirect damages will be reduced from $65,179 to $6,333, a reduction of 91 percent (table 5). Two percent of the reduction will accrue due to land treatment, while the other 89 percent reduction will result from the structural measures. Annual damage reductions attributable to the project, including those from land treatment, average $7,673 for crop and pasture damages, $9,150 for utilities, $22,499 for residential, $10,767 for business and industrial, $392 for flood plain scour, $182 for overbank deposition of sediment and $8,183 for indirect damage (table 5).

The total average annual flood damage reduction benefits, including floodwater damage reduction, reduction of sediment deposition on flood plain lands, reduction in flood plain scour damage and the reduction of indirect damages, are estimated to average $58,846 annually, of which $57,451 will be the result of structural measures.

Enhancement benefits that accrue to the urban area are estimated to be $18,632 annually. This is the amortized amount of the increase in value of land and capital investments due to flood protection.

Recreation water stored in the multiple-purpose structure will produce $21,000 benefits annually. Estimated use will be 14,000 visitor days, valued at $1.50 per visitor day.

Secondary benefits stemming from and induced by the recreation and flood prevention aspects of the project are estimated to average $8,908 annually. The total average annual benefits from structural measures, including damage reduction benefits, enhancement benefits, recreational benefits and secondary benefits are estimated to be $105,991 annually.

Redevelopment benefits were not used for project justification since the watershed is not located in an area designated by the Secretary of Agriculture under the Area Redevelopment Act.

COMPARISON OF BENEFITS AND COSTS

The average annual cost of structural measures (amortized total installation cost, plus operation and maintenance) is $57,708. The installation of the structural measures is expected to produce average annual primary benefits of $97,083. The ratio of primary benefits to costs will be 1.7 to 1.

Total benefits amounting to $105,991, including secondary benefits, from the structural measures will provide a benefit-cost ratio of 1.8 to 1 (table 6).

PROJECT INSTALLATION

The sponsoring organizations, with the assistance of the Extension Service, Vocational Agriculture and other interested agencies, will carry out the educational phase of the program. This will be accomplished by conducting general information meetings and local farm meetings, preparing radio and press releases, and using other methods of getting information to landowners and operators and other interested groups in the watershed. This will help achieve understanding and stimulate participation in the entire plan.

Land treatment measures will be established by the landowners and operators in cooperation with the East Canadian County and Central North Canadian River Soil and Water Conservation Districts during the 5-year project installation period. Progress in establishing land treatment measures will be kept ahead of installation of structural measures by concentrating activities in the drainage area above the proposed structures. The Soil Conservation Service, through the soil and water conservation districts, is giving technical assistance in the planning and application of these measures under their going programs. Technical assistance will be accelerated by assignment of additional personnel, as needed, to assure satisfactory planning progress and the application of the planned measures within the project installation period.

The governing body of the soil and water conservation districts, with the assistance of the city of El Reno, will arrange for meetings according to

a definite schedule. By this means and by individual contacts, they will encourage the landowners and operators within the Four Mile Creek watershed to adopt and carry out soil and water conservation plans on their farms. District-owned equipment will be made available to the landowners in accordance with the present working arrangements.

The city of El Reno will contract for all structural measures, including structure site 1, 4.80 miles of stream channel improvement and its appurtenances and the minimum basic facilities for recreation. The general sequence for the installation of structural measures will be as follows:

1. Multiple-Purpose Structure No. 1.

2. Basic Recreational Facilities.

3. Channel Improvement and Appurtenances.

The local sponsors will provide, at no cost to the Federal government, all the land, easements, rights-of-way, roads, utilities, houses and other improvements, and their removal or relocation as needed for the construction of 4.80 miles of stream channel improvement. The East Canadian County and Central North Canadian River Soil and Water Conservation Districts and the Board of County Commissioners will assist the city of El Reno in obtaining land, easements, and rights-of-way.

Land, easements, and rights-of-way on 470 acres needed for multiple-purpose structure 1 and the recreational facilities will be cost-shared with the local share being 50 percent and Public Law 566 funds furnishing 50 percent of the costs actually expended for this purpose. Perpetual easements will be acquired on 202 acres by the local sponsors at no cost to the Federal government. In addition, an easement will be obtained on 103 acres of Federal land in which there will be no cost sharing. Total area needed for the recreational development and multiple-purpose structure is 775 acres. The local sponsors also will furnish the local share of funds for the following: (1) construction cost allocated to recreational water storage, and (2) construction cost and installation services performed under contract for minimum basic facilities.

The legal cost incurred in acquiring land, easements, and rights-of-way for the recreational development will be furnished by the city of El Reno. Technical assistance will be provided by the Soil Conservation Service to assist in the preparation of plans and specifications, supervision of construction, preparation of contract payment estimates, final inspection, execution of certificates of completion and related tasks for the establishment of the planned structural measures.

A schedule to establish the structural measures within a 5-year period will be developed and adjusted from year to year on the basis of any significant changes in the plan found to be mutually desired by the cooperating parties and in line with actual appropriations and accomplishments.

FINANCING PROJECT INSTALLATION

Federal assistance for carrying out the works of improvement as described in this work plan will be provided under the authority of the Watershed Protection and Flood Prevention Act (Public Law 566, 83rd Congress, 68 Stat. 666), as amended.

All necessary land, easements, rights-of-way, and removal or relocation of roads, pipelines, utilities, and improvements will be obtained before Federal financial assistance is made available for installation of structural measures.

Construction of the planned structural measures will be started as soon as the project is approved, the contracting agency (city of El Reno) has funds available and is prepared to discharge its responsibilities, Public Law 566 funds are available, the necessary easements have been obtained and operation and maintenance agreements have been executed.

The city of El Reno will provide the local share of the financial needs for all structural measures. Bonds have been issued and funds are now available for what is estimated to be the major portion of needed funds for the project installation. It is proposed to issue additional bonds, if and as needed, to complete the installation of the project.

The County Agricultural Stabilization Conservation Committee will cooperate with the sponsoring organizations by selecting and providing financial assistance for those land treatment measures which will meet the conservation objectives in the shortest possible time.

The soil and water conservation loan program of the Farmers Home Administration is available to all eligible farmers and ranchers in the area. Educational meetings will be held in cooperation with other agencies to outline the services available and eligibility requirements. Present clients will be encouraged to cooperate in the project.

PROVISIONS FOR OPERATION AND MAINTENANCE

Land Treatment Measures

Land treatment measures will be maintained by the landowners or operators of the farms on which the measures are installed under agreement with the East Canadian County and Central North Canadian River Soil and Water Conservation Districts. Representatives of the soil and water conservation districts will make or cause to be made periodic inspection of the completed land treatment measures to determine maintenance needs and to encourage landowners and operators to perform needed maintenance. They will make district-owned equipment available for this purpose.

Structural Measures

The city of El Reno will be responsible for the operation and maintenance of the structural measures. Joint responsibility for operation and maintenance will be assumed by the East Canadian County and Central North Canadian River Soil and Water Conservation Districts and the city of El Reno.

The annual operation and maintenance cost of the multiple-purpose structure is estimated at $300, basic recreational facilities $11,600 (includes replacement cost over 100-year evaluation period), and the stream channel improvement $8,000. The estimated annual operation and maintenance cost for all structural measures is $19,900, based on long-term price levels.

Funds for accomplishing the maintenance work will be obtained and furnished by the city of El Reno. The city will operate and maintain all structural measures, including the multiple-purpose structure, basic recreational facilities and the channel improvement and appurtenances. The recreational development will be included in the city park system with custodial, policing, garbage collection and other operational services furnished by the city. A portion of the needed maintenance funds will be met by fees from the use of the recreational facilities; additional needs will be from other city funds. Fees will not exceed the amortized value of the initial investment plus operation and maintenance cost.

The structural measures will be inspected after each heavy rain or stream flow or at least annually. For the multiple-purpose structure, items of inspection will include, but will not be limited to, the condition of the principal spillway and its appurtenances, the vegetative cover of the earth fill and the emergency spillway. For the improved channel and its appurtenances, items of inspection will include, but will not be limited to, the degree of scour, silting, and bank erosion, obstruction to flow caused by debris lodged against bridges, the condition of vegetation, stabilization structures, side inlets, and drains. Inspection of the recreational facilities will include safety, sanitary, and other functional features. The items of inspection are those most likely to require maintenance.

The sponsoring local organizations will maintain a record of all maintenance inspections and maintenance work done. These records will be available to Soil Conservation Service personnel.

The necessary maintenance work will be accomplished through the use of contributed labor and equipment, by contract, by hourly-rate contract, or by a combination of these methods.

The Soil Conservation Service, through the soil and water conservation districts, will participate in the operation and maintenance only to the extent of furnishing technical assistance to aid in inspections and

furnishing technical guidance and information necessary for the operation and maintenance program.

Provisions will be made for free access of district, State and Federal representatives to inspect all structural measures and their appurtenances at any time.

The sponsoring organizations fully understand their obligations for maintenance and will execute specific maintenance agreements prior to the issuance of any invitation to bid.

TABLE 1 - ESTIMATED PROJECT INSTALLATION COST

Four Mile Creek Watershed, Oklahoma

Installation Cost Item	Unit	Number To Be Applied 1/	Estimated Cost (dollars) 2/ Public Law 566 Funds	Other 3/	Total
LAND TREATMENT					
Soil Conservation Service					
Cropland	Acre	3,639	-	24,038	24,038
Range	Acre	1,457	-	3,693	3,693
Improved Pasture	Acre	570	-	3,653	3,653
Miscellaneous Land	Acre	120	-	12,000	12,000
Technical Assistance			4,000	3,600	7,600
SCS Subtotal			4,000	46,984	50,984
TOTAL LAND TREATMENT			4,000	46,984	50,984
STRUCTURAL MEASURES					
Soil Conservation Service					
Multiple-Purpose Structure	No.	1	239,018	20,982	260,000
Minimum Basic Facilities	No.	1	30,000	30,000	60,000
Stream Channel Improvement	Mile	4.80	198,400	-	198,400
Grade Stabilization Structure	No.	1	35,000	-	35,000
SCS Subtotal			502,418	50,982	553,400
Subtotal - Construction			502,418	50,982	553,400
Installation Services					
Soil Conservation Service					
Engineering Services			89,618	2,010	91,628
Other			40,202	865	41,067
SCS Subtotal			129,820	2,875	132,695
Subtotal - Installation Services			129,820	2,875	132,695
Other Costs					
Land, Easements and Rights-of-Way			117,500	281,500	399,000
Administration of Contracts			-	3,000	3,000
Subtotal - Other			117,500	284,500	402,000
TOTAL STRUCTURAL MEASURES			749,738	338,357	1,088,095
TOTAL PROJECT			753,738	385,341	1,139,079
SUMMARY					
Subtotal SCS			753,738	385,341	1,139,079
TOTAL PROJECT			753,738	385,341	1,139,079

1/ No land treatment proposed on Federal land; however, a small portion of the multiple-purpose structure and minimum basic facilities are on Federal land.

2/ Price Base: 1962

3/ Includes reimbursement from ACP and other Federal funds under going program.

December 1963

TABLE 1A - STATUS OF WATERSHED WORKS OF IMPROVEMENT
(at time of Work Plan preparation)

Four Mile Creek Watershed, Oklahoma

Measures	Unit	Number Applied To Date	Total Cost 1/ (dollars)
LAND TREATMENT			
Conservation Cropping Systems	Acre	6,389	41,529
Contour Farming	Acre	2,519	5,038
Cover and Green Manure Crop	Acre	2,272	11,360
Crop Residue Use	Acre	5,369	8,054
Pasture Planting	Acre	115	2,300
Range Deferred Grazing	Acre	1,410	2,115
Range Proper Use	Acre	2,253	1,127
Range Seeding	Acre	38	342
Diversion	Foot	100,452	6,027
Grassed Waterway or Outlet	Acre	25	3,125
Farm Pond	Number	19	12,350
Terrace Gradient	Foot	241,085	12,054
Drainage Field Ditch	Foot	9,513	951
TOTAL	xxx	xxx	106,372

1/ Price Base: 1962.

December 1963

TABLE 2 - ESTIMATED STRUCTURE COST DISTRIBUTION

Four Mile Creek Watershed, Oklahoma
(Dollars) 1/

Structure Site Number or Name	Installation Costs - Public Law 566 Funds					Installation Costs - Other Funds						Total Installation Cost
		Installation Services		Land Easements and R/W	Total Public Law 566		Installation Services		Adm. of Contracts	Land Easements and R/W 2/	Total Other	
	Construction	Engineering	Other			Construction	Engineering	Other				
Multiple-Purpose Structure No. 1	239,018	43,050	18,450	86,000	386,518	20,982	-	-	600	120,400	141,982	528,500
Basic Recreational Facilities	30,000	2,010	865	31,500	64,375	30,000	2,010	865	600	33,100	66,575	130,950
Subtotal	269,018	45,060	19,315	117,500	450,893	50,982	2,010	865	1,200	153,500	208,557	659,450
Stream Channel Improvement 3/	198,400	38,158	17,887	-	254,445	-	-	-	1,500	128,000	129,500	383,945
Grade Stabilization Structure 101	35,000	6,400	3,000	-	44,400	-	-	-	300	-	300	44,700
TOTAL	502,418	89,618	40,202	117,500	749,738	50,982	2,010	865	3,000	281,500	338,357	1,088,095

1/ Price Base: 1962.

2/ Includes legal fees.

3/ Construction cost includes cost of alteration of railroad bridges and abutments.

December 1963

TABLE 3 - STRUCTURE DATA - MULTIPLE-PURPOSE STRUCTURE
Four Mile Creek Watershed, Oklahoma

Item	Unit	Structure Number 1	Total
Drainage Area	Sq.Mi.	7.03	7.03
Storage Capacity 1/			
Sediment Pool (100 Years)	Ac.Ft.	495	495
Sediment in Recreation Pool	Ac.Ft.	214	214
Sediment in Detention Pool	Ac.Ft.	109	109
Recreation Pool	Ac.Ft.	709	709
Floodwater Detention Pool	Ac.Ft.	2,865	2,865
Total	Ac.Ft.	4,392	4,392
Surface Area 1/			
Sediment Pool	Acre	86	86
Recreation Pool	Acre	170	170
Detention Pool	Acre	405	405
Volume of Fill	Cu.Yd.	248,000	248,000
Elevation Top of Dam 1/	Foot	1,379.1	1,379.1
Maximum Height of Dam 1/	Foot	40	xxx
Emergency Spillway			
Crest Elevation 1/	Foot	1,373.6	xxx
Bottom Width 1/	Foot	400	xxx
Type		Veg.	xxx
Percent Chance of Use 2/		1	xxx
Future Condition II - Curve No.		80	xxx
Emergency Spillway Hydrograph			
Storm Rainfall (6-hour)	Inch	11.59	xxx
Storm Runoff	Inch	9.05	xxx
Velocity of Flow (V_c) 3/	Ft./Sec.	3.6	xxx
Discharge Rate 3/	C.F.S.	400	xxx
Maximum Water Surface Elevation 1/ 3/	Foot	1,374.4	xxx
Freeboard Hydrograph			
Storm Rainfall (6-hour)	Inch	28.98	xxx
Storm Runoff	Inch	26.18	xxx
Velocity of Flow (V_c) 3/	Ft./Sec.	10.4	xxx
Discharge Rate 3/	C.F.S.	12,900	xxx
Maximum Water Surface Elevation 1/ 3/	Foot	1,379.1	xxx
Principal Spillway Capacity (Maximum)	C.F.S.	71	xxx
Capacity Equivalents			
Sediment Volume	Inch	1.32	xxx
Sediment in Recreation Pool	Inch	0.57	xxx
Sediment in Detention Pool	Inch	0.29	xxx
Recreation Volume	Inch	1.89	xxx
Detention Volume	Inch	7.64	xxx
Spillway Storage	Inch	7.60	xxx
Class of Structure		C	xxx

1/ Subject to minor adjustments in final design stage. Major changes will require work plan revision.
2/ Based on regional analysis of gaged runoff.
3/ Maximum during passage of hydrograph.

December 1963

TABLE 3A - STRUCTURE DATA

GRADE STABILIZATION STRUCTURE

Four Mile Creek Watershed, Oklahoma

Site Number	Drainage Area (Sq.Mi.)	Drop (Feet)	Concrete (Cu.Yds.)	Type Structure
101	16	10	230	Drop

December 1963

TABLE 3B - STRUCTURE DATA

CHANNELS

Four Mile Creek Watershed, Oklahoma

Channel Designation	Station Numbering: For Reach: Station (100 ft.)	Station (100 ft.)	Water-shed Area (sq. mi.)	Required: Channel Capacity 1/ (cfs)	Planned Channel Capacity (cfs)	Aver-age Bottom Width (ft.)	Average Side Slope	Aver-age Depth (ft.)	Hydrau-lic Grade Slope (ft./ft.)	Velocity at Designed Depth (ft./sec.)	Volume of Excavation (1000 cu. yds.)
Channel No. 1	120+00	154+00	8.7	1,170	1,200	26	2:1	6.5	.0012	4.73	40.0
	154+00	190+00	10.9	2,390	2,400	26	2:1	9.4	.0012	5.75	45.7
	190+00	215+00	13.0	2,390	2,400	30	2:1	9.4	.0010	5.38	34.5
	215+00		15.8	3,110	3,200	45	2:1	9.4	.0010	5.67	-
	Transition Reach (From Trapazoidal to Parabolic)								.0010	Channel Slope	10.3
		225+00	15.8	1,950	1,950 2/	112	Parabolic	6.6		4.03	
	225+00	294+00	15.8	1,950	1,950	112	Parabolic	6.6	.0010	4.03	70.0
	294+00		Drop Structure	-	2,750 3/						
	294+00	315+00	16.0	1,975	Natural Channel - Clear trees from bottom of channel						-
Channel No. 2	160+00	209+00	1.8	1,850	1,850	20	2:1	8.8	.0013	5.59	60.1
	209+00	215+00 4/	2.8	2,130	2,140	20	2:1	9.4	.0013	5.79	8.1

Total Length = 4.80 Miles
Total Excavation = 268,700 Cubic Yards

1/ Runoff from uncontrolled area, plus release flow from structure on Channel No. 1.
2/ Parabolic channel designed for 10-year frequency runoff. Design based on SCS TP-61, Vegetative Channel Design.
3/ 50-year frequency storm runoff.
4/ Station 215+00 on Channel No. 1 and Channel No. 2 is the same station.

TABLE 4 - ANNUAL COST

Four Mile Creek Watershed, Oklahoma

(Dollars)

Evaluation Unit	Amortization of Installation Cost 1/	Operation and Maintenance Cost 2/	Other Economic Cost 3/	Total
Multiple-Purpose Structure, Stream Channel Improvement, Grade Stabilization Structure and Basic Recreational Facilities	34,438	19,900	3,370	57,708
TOTAL	34,438	19,900	3,370	57,708

1/ Installation costs are based on 1962 prices, amortized over 100 years at 3.0 percent.

2/ Long-term prices based on projections by ERS, September 1957. Operation and maintenance cost of basic recreational facilities is $11,600 and includes replacement cost of the facilities during the 100-year evaluation period.

3/ Opportunity costs for other uses in the multiple-purpose structure and recreational areas exceeded the amortized amount of the appraised acquisition value by $3,370.

December 1963

TABLE 5 - ESTIMATED AVERAGE ANNUAL FLOOD DAMAGE REDUCTION BENEFITS

Four Mile Creek Watershed, Oklahoma

(Dollars) 1/

Item	Estimated Average Annual Damage: Without Project	Estimated Average Annual Damage: With Project	Damage Reduction Benefit
Floodwater			
Crop and Pasture	12,971	5,298	7,673
Utilities	9,150	0	9,150
Residential	22,499	0	22,499
Business and Industrial	10,767	0	10,767
Subtotal	55,387	5,298	50,089
Sediment			
Overbank Deposition	227	45	182
Erosion			
Flood Plain Scour	806	414	392
Indirect	8,759	576	8,183
TOTAL	65,179	6,333	58,846

1/ Price Base: Long-term prices as projected by ERS, September 1957.

December 1963

TABLE 6 - COMPARISON OF BENEFITS AND COSTS FOR STRUCTURAL MEASURES

Four Mile Creek Watershed, Oklahoma

(Dollars)

Evaluation Unit	AVERAGE ANNUAL BENEFITS 1/					Average Annual Cost 2/	Benefit-Cost Ratio
	Flood Prevention						
	Damage Reduction	Enhancement: Urban	Recreation	Secondary	Total		
Multiple-Purpose Structure, Stream Channel Improvement, Grade Stabilization Structure, and Basic Recreational Facilities	57,451	18,632	21,000	8,908	105,991	57,708	1.8:1
Total	57,451	18,632	21,000	8,908	105,991	57,708	1.8:1

1/ Price Base: Long-term prices as projected by ERS, September 1957.

2/ From table 4.

3/ In addition, it is estimated that land treatment measures will provide annual flood reduction benefits of $1,395 annually.

December 1963

INVESTIGATIONS AND ANALYSES

Cover Conditions and Land Use

The soil-cover determinations were made from existing work unit records, soil surveys, and field inspections. Additional information to verify soil-cover conditions was obtained from detailed studies made for determination of sediment rates to structure.

The land use on the upland was determined from existing work unit records and from detailed sediment source studies on 30 percent of the total drainage area in the watershed. The land use of the flood plain was planimetered from the flood plain map that was developed during the hydrologic and economic investigations.

Project Objectives

Watershed problems were discussed with the sponsoring local organizations and agreement was reached on the following project objectives:

1. Apply the needed land treatment measures, based on current needs, which remain to be applied in the watershed and which contribute directly to watershed protection, flood prevention and sediment control.

2. Obtain an average annual flood damage reduction of 70 to 80 percent on agricultural damages to the flood plain land and protection to the urban areas of El Reno from storm runoff that will occur on an average of once in 100 years. Stream channel improvement to be planned if the desired level of protection is not reached in the urban area by the installation of the multiple-purpose structure.

3. Locate and evaluate water supply storage in a multiple-purpose structure for a recreational development.

4. Drainage needs can be met by on-farm drainage systems for which suitable outlets are available, therefore, drainage is not needed as a project objective.

Land Treatment Measures

The amount and cost of land treatment to be applied during the project installation period are shown in table 1. The measures in table 1A which have been applied with assistance from Soil Conservation Service are identified in accordance with the terminology in the Soil Conservation Service National Records and Reports Handbook. The hydraulic, hydrologic, sedimentation and economic investigations provided data on the effects of the measures in terms of the reduction of flood damages resulting from such treatment. Although

measurable benefits would result from application of needed land treatment measures, it was apparent that structural measures would be needed to attain the degree of watershed protection and flood damage reduction desired.

Structural Measures

Structural Measures which would be feasible to install were determined. The study made and the procedures used in that determination were as follows:

1. A base map of the watershed was prepared showing the watershed boundary, drainage pattern, system of roads and other pertinent information. A stereoscopic study of consecutive 4-inch aerial photographs was used to locate possible floodwater retarding and multiple-purpose structure sites, the limits and the area of the flood plain and points where valley cross sections should be taken for the determination of hydraulic characteristics and for flood routing purposes. This information was placed on the watershed base map for use in field surveys. Cross sections of the flood plain were surveyed at the selected locations (figure 5).

   Data developed from these cross sections permitted the computation of peak discharge-damage relationships for various flood flows. A map of the flood plain was prepared showing land use, cross section locations and other pertinent information.

2. A field examination was made of all possible floodwater retarding and multiple-purpose structure sites previously located stereoscopically. Sites which did not show good storage possibilities or which would inundate highways or expensive improvements which would make the cost so high that the site would not be economically feasible were dropped from further consideration.

   Alternate systems of structural measures that would meet project objectives were investigated.

   Surveys, preliminary geological investigations, preliminary designs and cost estimates were made for stream channel improvement on Four Mile Creek.

3. Damages resulting from floodwater, sediment and erosion were determined from damage schedules and surveys of the flood plain area. Reduction in these damages by the installation of various combinations of structural measures was estimated on the basis of reduction of area depth of inundation as determined by flood routings. Calculations of flood damages

were made according to flood routings without project and with proposed works of improvement installed. Benefits so determined were allocated to individual measures or groups of interrelated measures on the basis of the effect of each on reduction of damages. Alternate systems of structures were evaluated and the combination selected which met project objectives at lowest cost.

4. The combined project for flood prevention, including land treatment measures, multiple-purpose structures and stream channel improvement was evaluated. Studies were made and data developed to show the total cost of each type of measure and the portion of the cost to be borne by the participants. A summation of the total costs for all planned measures is shown in table 1 and table 2. A cost table also was developed to show the annual installation cost, annual maintenance cost and total annual cost of the structural measures (table 4).

5. The local sponsors requested that a site be used for a recreational development. Site 1 is suitable for a multiple-purpose structure and there will be available in the reservoir 495 acre-feet of sediment storage, 323 acre-feet of sediment reserve, 709 acre-feet of recreational water supply storage and 2,865 acre-feet of detention storage. The combined aggregate capacity for all purposes will be 4,392 acre-feet.

Engineering Investigations

Tentative locations for 2 floodwater retarding structures, 1 multiple-purpose structure, and stream channel improvement were selected and a study made to determine the least costly system that would meet the project objectives.

One multiple-purpose structure (Site 1) and 4.80 miles of stream channel improvement are the most feasible system of structural measures which will provide the degree of protection desired by the sponsoring local organizations and meet the requirements of the Watershed Protection Handbook.

1. Considerations for the selections of the structural measures included in the work plan are as follows:

   a. Site 1 combined with the 4.80 miles of stream channel improvement are economically more feasible than including additional floodwater retarding structures, since the needed channel improvement would not be eliminated.

2. Topographic map with 4-foot contour intervals and a scale of

1 inch = 400 feet was developed from engineering surveys of the pool area of the site.

The height of the dam and the size of the pools were determined by the storage volume needed to detain the runoff from the design storm and to provide the additional storage needed for sediment and recreation storage.

3. A structure data table was developed to show the drainage area, storage capacity planned for floodwater detention, sediment, and recreational water supply storage, release rate of the principal spillway, emergency spillway capacity, area inundated by the pools, and other pertinent data for the multiple-purpose structure (table 3).

4. Floodwater detention capacity was planned in the structure to detain the expected runoff from a 100-year storm event, as determined by a regional analysis of stream gage records in areas of similar geologic formation, topography and average annual rainfall. Use of the emergency spillway, as shown in table 3, has a one percent chance of occurrence. The detention volume exceeds the minimum requirements set forth in Engineering Memorandum SCS-27.

5. In the study made for improving the 4.80 miles of stream channel, cross sections were surveyed, as needed, along Channel No. 1, and topographic surveys were made along Channel No. 2. Representative soil samples were analyzed in the laboratory and the findings were used to determine permissible velocities. Design criteria to determine the channel stability was based on the Tractive Force equation. The channels above station 215+00 were designed, based on Tractive Force equation, to carry the peak discharge produced by the runoff from a 12-hour, 100-year frequency storm with the multiple-purpose structure in place. Below station 225+00 the channel was designed, based on "Vegetative Channel Design" USDA-SCS TP-61, to carry the peak discharge produced by the runoff from a 12-hour, 10-year frequency storm with the multiple-purpose structure in place, from stations 215+00 to 225+00 the channel was designed as a transition reach.

   Structure data tables were developed showing the drainage area, the required channel capacity, the planned channel capacity, average bottom width and other pertinent data for each section of proposed channel (table 3B). Cost estimates for the stream channel improvement are shown in table 2.

6. Channel No. 1 was designed using trapezoidal sections without vegetation for the entire length. In keeping with Tractive Force criteria, two grade stabilization structures would have been required in the agricultural area downstream from the railroad tracks. By utilizing vegetation, Handbook of Channel Design (SCS-TP-61) criteria, a more economical parabolic channel design was developed for the lower reach to the river. It was found that one of the two grade stabilization structures could be eliminated and excavation

volumes decreased. The work plan proposes the use of the more economical parabolic section design in this lower reach.

Hydraulic and Hydrologic Investigations

The following steps were taken as part of the hydrologic investigations and determinations:

1. Precipitation records collected by the U. S. Weather Bureau at El Reno and Geary, Oklahoma, indicated that the storm of September 12, 1961, which produced the most recent major flood was a 12-hour duration storm which would be expected to occur once in 60 years, on an average.

   Technical Paper No. 40, U. S. Weather Bureau, was used to determine the 12-hour duration 100-year, 25-year, 10-year, and 2-year frequency storms. The pattern of these storms was assumed to be the same as the rain of September 12, 1961, which was obtained from the hourly recording gage at Geary, Oklahoma, approximately 20 miles northwest of the watershed.

2. The present hydrologic condition of the watershed was determined by classifying the soil as to hydrologic properties with the assistance of the soil scientist and a study of the work unit records. A reconnaissance survey of the watershed was made by the party geologist and hydrologist to obtain additional data to verify the hydrologic condition.

   The future hydrologic condition of the watershed was determined from information furnished by the work unit conservationists showing the changes in land use that could be expected with an accelerated land treatment program during the installation period. Runoff curve numbers were computed from the soil cover complex data and used with Figure 3.10-1, National Engineering Handbook, Section 4, Supplement A, to determine the amount of runoff from storms of various sizes.

3. Engineering surveys were made of channel and valley cross sections selected to represent adequately the stream hydraulics and flood plain area. Preliminary locations for cross sections were made by stereoscopic examination of aerial photographs of the flood plain. The final locations were selected on the ground, giving due consideration to the needs of the economist and geologist. The evaluation reaches were delineated in conference with the economist and geologist.

4. Cross section rating curves were computed from field survey data collected as described in Item 3 above, by solving water surface profiles for various discharges. The water surface profiles were computed by the use of the IBM 650 computer.

5. Composite hydrographs were developed for incremental areas using the procedure in National Engineering Handbook, Section 4, Supplement A, Chapter 15. The composite hydrograph of the runoff produced by the September 12, 1961, storm when routed, checked favorably with reliable high water marks of that storm. The coefficient method of flood routing was used to establish the runoff peak discharge relationship for the September 12, 1961, storm, also for the 100-year, 25-year, and 10-year frequency storm events for watershed conditions that would exist due to:

   a. The present conditions of the watershed remaining static.

   b. The installation of land treatment measures for watershed protection.

   c. The installation of land treatment measures and floodwater retarding structures.

   d. The installation of land treatment measures, floodwater retarding structures and stream channel improvement.

6. The runoff from the 12-hour duration, 100-year frequency storm was routed and the area flooded was considered as flood plain for evaluation of damages in the urban area. The area that would be inundated by a flood of this magnitude is outlined on Figure 3 for watershed conditions a, and d, listed in Item 5.

7. The appropriate spillway design storm, and storm pattern, were selected from Figures 3.21-1, 3.21-4 and 5, National Engineering Handbook, Section 4, Supplement A, in accordance with criteria contained in Washington Engineering Memorandum No. 27 (OK-22).

8. Spillway design and freeboard hydrographs were developed for the multiple-purpose recreation and floodwater retarding structure by the distribution graph method. The combination of emergency spillway width, depth and elevation for the most economical structure was estimated by an empirical equation.

   The most economical site was then routed using the Goodrich

flood routing method described on page 5.8-12 of the National Engineering Handbook, Section 5.

9. The runoff from a 12-hour, 100-year frequency storm under present conditions would cause a peak discharge of 3,690 c.f.s. at reference valley section 11 (figure 5); after installation and full functioning of the project the peak discharge would be reduced to 2,230 c.f.s. at the reference valley section.

Reservoir Operation

A reservoir operation study was made on the recreation water storage portion of the multiple-purpose reservoir using the following data:

1. Storage data tables of the site were developed and plotted as shown in figure 2.

2. The most critical drought period of record (water years 1951 through 1957) was selected for the study.

3. The U. S. Geological Survey gage records on Turkey Creek, near Drummond, Oklahoma, were used to obtain monthly inflow in acre-feet per square mile.

4. The following records were used to compute the net evaporation from the reservoir surface:

   U. S. Weather Bureau Class A pan records at Lake Hefner,
   U. S. Weather Bureau standard rain gage at El Reno, Oklahoma,
   U. S. Weather Bureau Technical Paper 37,
   U. S. Geological Survey Circular 229, Water Loss Investigations, Volume 1, Lake Hefner Studies.

The reservoir was operated through the selected study period (1951 through 1957) to determine the minimum storage and surface area reached due to loss to evaporation on the recreation pool. The results of these operations are shown in figure 4. During the peak season of 1954 and part of 1955 the reservoir operated into the sediment pool. The reservoir operated within the recreation pool during the peak season for the selected study period with the exception of the extreme drouth period of 1954 and 1955. It is concluded the recreation pool will be sufficient except during extended drouth periods.

Sedimentation Investigations

Field surveys of the sedimentation problems of the Four Mile Creek watershed were made in accordance with the Geologic Section of the Oklahoma Planning

Handbook and Technical Release No. 12, "Procedure for Computing Sediment Requirements for Retarding Reservoirs" (September 1959).

Field studies included reconnaissance surveys of geology, physiography, studies of overbank sediment deposits, flood plain scour, streambank erosion and the nature of the channels and valleys on or near the valley cross sections. Borings were made along or near 75 percent of the agricultural valley sections to determine the extent, depth and texture of sediment and the resultant effect on productivity. Tabular summaries of these findings were submitted to the economist for use in calculating pecuniary damages.

Channel Stability Studies

Nine borings were made with a truck-mounted power auger to determine foundation conditions for the proposed channel improvement. The holes were bored to a depth of 16 feet and samples collected from each horizon. These samples were submitted to the Materials Testing Section of the Soil Conservation Service at Fort Worth, Texas, for analyses. The Tractive Force theory was applied to the analyses to determine the relative stability of the soils and the results were used as a guide in the design of the proposed channel.

Two general soil types predominate throughout the length of the proposed channel. From U. S. Highway 66 to the general area of the municipal sewage lift station on Four Mile Creek, CL or cohesive soils underlie the channel. From the lift station to the mouth of Four Mile Creek, SM, or non-cohesive soils underlie the channel. The non-cohesive soils are highly susceptible to erosion and, therefore, the design of the lower segment of Channel No. 1 necessitated decreases in gradient and depth of flow from those used in design for the cohesive soils.

Sediment Source Studies

Sediment sources were investigated in the drainage area of the planned multiple-purpose water storage structure. Procedures outlined in the Oklahoma Watershed Planning Handbook and Technical Release No. 12 were followed.

The estimate of sediment derived from sheet erosion was taken from planimeteric data gathered from field studies and stereoscopic inspection of aerial photographs on all of the drainage area above the site. Erosion rates were calculated separately for each soil unit, slope and cover condition in the drainage area.

The average annual rate of sediment deposition in the structure is expected to be 1.16 acre-feet per square mile of drainage area. It is estimated that 98 percent of the gross erosion is derived from sheet erosion and 2 percent from road and streambank erosion. Factors affecting sediment yields such as the destruction of cover by fire, deterioration due to droughts and possible changes in land use were considered in calculating sediment storage capacity for the structure.

Geologic Investigations

A preliminary geologic investigation was made at the proposed site. This investigation included studies of the geologic formation, topography, borrow area, spillway and stream channel.

The site is located on the Blaine formation, Enid group, of lower Permian age. The Blaine formation contains massive beds of gypsum in some areas in Oklahoma but none are present in the watershed. The formation consists largely of moderately soft red shale with stringers of siltstone. A stratum of moderately hard, thin-bedded siltstone in the right abutment could entail rock excavation in the emergency spillway.

Geologic conditions at the site are described on Form SCS-375, "Preliminary Geologic Investigation of Dam Sites". This is on file as a part of work plan substantiating data. Detailed investigations and laboratory analyses will be made prior to final design of the structure.

Economic Investigations

Selection of Evaluation Reaches

Because of the diversity of damageable values and flood plain characteristics, the flood plain was divided into six evaluation reaches, see figure 5.

Determination of Nonagricultural Damages

Since the major floodwater damages in the watershed are to nonagricultural property, the synthetic frequency method of analysis was used. Information was collected in the field by interviews covering 20 percent of the flood area to determine damages from the flood of 1953, which was a 60-year event, and several lesser floods. A flood zone map was drawn showing the location of all property subject to flooding. The value of each individual property was appraised for use in the valuation of damages. High water marks from the experienced floods were used to determine peak stages which in turn were related to stages calculated for the synthetic series and stage damage curves were developed to cover the range of damage producing floods. Average annual damage under the present state of development was calculated for each evaluation reach. It was estimated that normal improvements to existing residential developments and the quantity and price of household furnishings will increase 25 percent by the end of the project life. Therefore, damage to existing development was increased to reflect the gradual accrual of these values discounted to present worth.

Damage information to streets, bridges, utilities and parks was obtained from city officials and from residents of the watershed.

Nonagricultural indirect damages include rerouted or interrupted travel and inconvenience and expense sustained as a result of interrupted public utility

service. Information regarding damages of this type was obtained from local residents and public officials. It is estimated that indirect damages would be 15 percent of the direct damages to residential property and 20 percent of the direct damages to utilities, businesses and industries.

Determination of Agricultural Damages

Agricultural damage estimates were based on schedules obtained in the field covering approximately 30 percent of the agricultural flood plain. These schedules covered land use, crop distribution, yields and historical data on flooding and flood damages.

The flood plain land use was mapped in the field. Estimates of normal flood-free yields were based on data obtained from schedules, supplemented by information supplied by other agricultural workers in the area and data from secondary sources. Yields are projected in accordance with studies made by ERS. Long-term prices as projected by ERS were used. The costs of harvesting and other production inputs were calculated and deducted from the gross value of the damage in the calculation of crop and pasture damage. Information from other nearby watersheds with similar cropping patterns and flood frequencies was used to evaluate the farmer information obtained and to determine the average annual damage to crops and pastures under existing conditions. Damages under future conditions were determined by reducing present condition damages in accordance with the reduction of flooding as shown by the hydrologic investigations.

The monetary value of the physical damage to the flood plain from erosion and from deposition of sediment was based on the net value of production lost, taking into account the time lag for recovery.

Important items of indirect agricultural damage are the interruptions of travel or detours due to flooding and additional expense for care of livestock. It was estimated that indirect damage to crop and pasture and other agricultural property would approximate 10 percent of the direct damage.

Determination of Benefits

Average annual damages within the watershed were calculated for conditions without a project, with land treatment installed and after installation of the completed project.

The difference between the damage after the installation of a phase of the project and that before its installation constituted the benefit from reduction of damage creditable to that phase.

At present there are several underdeveloped areas in the urban and industrial areas within the flood plain that are so frequently flooded that full development is not feasible at the present time.

These areas would be completely protected from a storm that could be expected once in 100 years on an average under present conditions. The City Planning Commission, with the help of consulting planners, has developed a comprehensive plan in which these areas are included. This plan was used as a guide in estimating enhancement benefits. As a result of this analysis, 170 acres were considered for enhancement during a 20-year period. The difference in market value before and after the project was estimated and converted to an average annual basis by applying a rate of return applicable to private investment in the building industry.

Recreation Benefits

Because of the level of development of facilities planned, a value of $1.50 per visitor day was used in estimating recreation value at multiple-purpose site. Benefits from recreation were based on the value of a visitor day of use and the estimated number of days of use annually. Determination of the number of visitor days of annual use was based on secondary data and field surveys made in the local area. The following factors were taken into consideration in determining the number of annual visitor days.

a. The area available for use.

b. Facilities available.

c. The population and population trends within a 50-mile radius of the site.

d. Competitive recreational development in the 50-mile radius area.

e. Policing and maintenance.

f. Accessibility of site.

g. Service facilities convenient to site.

h. Proposed level of admission charges.

i. Recreational capacity for sustained use.

j. The opportunities for different type of recreation by seasons.

k. The extent of storage depletion during periods of less than normal rainfall.

Secondary Benefits

Secondary benefits, the net increase in the value of goods and services generated by the project, will be realized by workers, processors and business

establishments in the trade area. The evaluation of these benefits was limited to those which will occur locally as a result of project installation.

Local secondary benefits were estimated to equal 10 percent of the primary benefits, with the exception of those resulting from reduction of indirect damage.

Appraisal of Land and Easements Value

The area that will be used for recreational purposes, the areas outside the recreational area that will be inundated by the normal pool and the detention pool and the areas that will be involved in channel improvement were excluded from the damage appraisal. The values of these lands for other potential uses were compared with appraised value of the sites for project purposes. Where such opportunity costs were greater than appraised values, the difference was shown as an other economic cost, table 4.

Details of Methodology

Details of the procedures used in the investigation are described in the Economic Guide for Watershed Protection and Flood Prevention.

Table A - Basic Recreational Facilities

Four Mile Creek Watershed, Oklahoma

Site No. 1

Item	Unit	Number	Unit Cost (dollars)	Amount 1/ (dollars)
1. Roads				
a. Improved 2/	Mile	3.0	6,500	19,500
b. Semi-improved 3/	Mile	2.1	3,000	6,300
2. Parking Areas				
a. Improved 2/	Sq.Yd.	10,000	0.40	4,000
b. Semi-improved 3/	Sq.Yd.	10,000	0.20	2,000
3. Utilities				
a. Water System (Each Side of Reservoir)	-	-	-	5,000
b. Electricity and Lighting		-	-	2,000
4. Sanitary Facilities 4/				
a. Latrines (Flush Type)	Each	2	2,500	5,000
b. Latrines (Pit Type)	Set	2	800	1,600
c. Garbage Can Holders (Below Ground)	Each	8	50	400
5. Picnic Facilities				
a. Tables (Concrete)	Each	24	100	2,400
b. Group Shelter	Each	2	2,500	5,000
c. Charcoal Grills	Each	10	75	750
6. Boating				
a. Boat Ramps	Each	2	800	1,600
b. Boat Dock	Each	1	800	800
7. Fishing Pier	Each	1	1,200	1,200
8. Landscaping and Vegetation	-	-	-	5,000
9. Fencing	Mile	4	800	3,200
Total - Recreational Facilities				65,750

1/ Includes construction and installation services costs.
2/ Improved roads and parking areas include grade, drainage and gravel.
3/ Semi-improved roads and parking areas include basic grade and drainage.
4/ Final designs and location to be approved by the State Health Department.

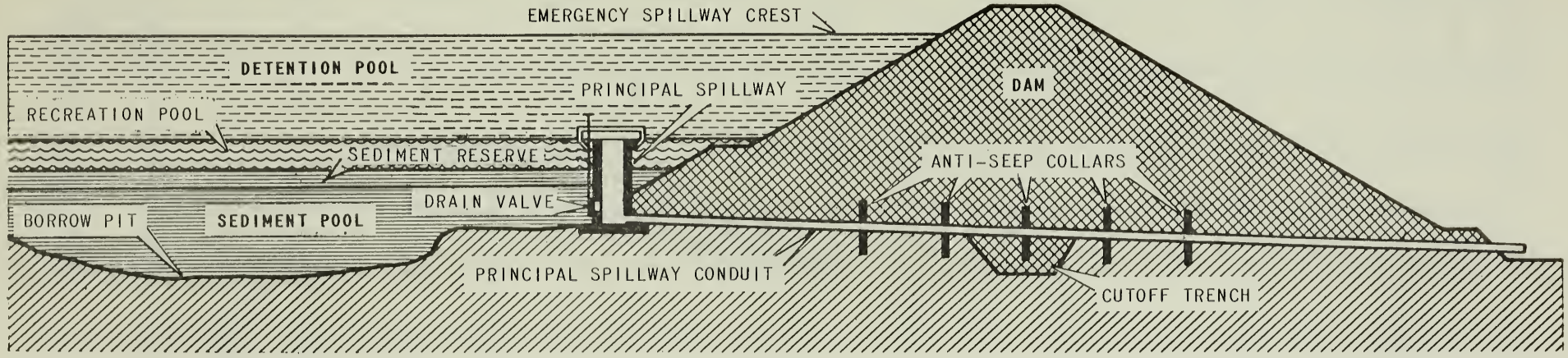
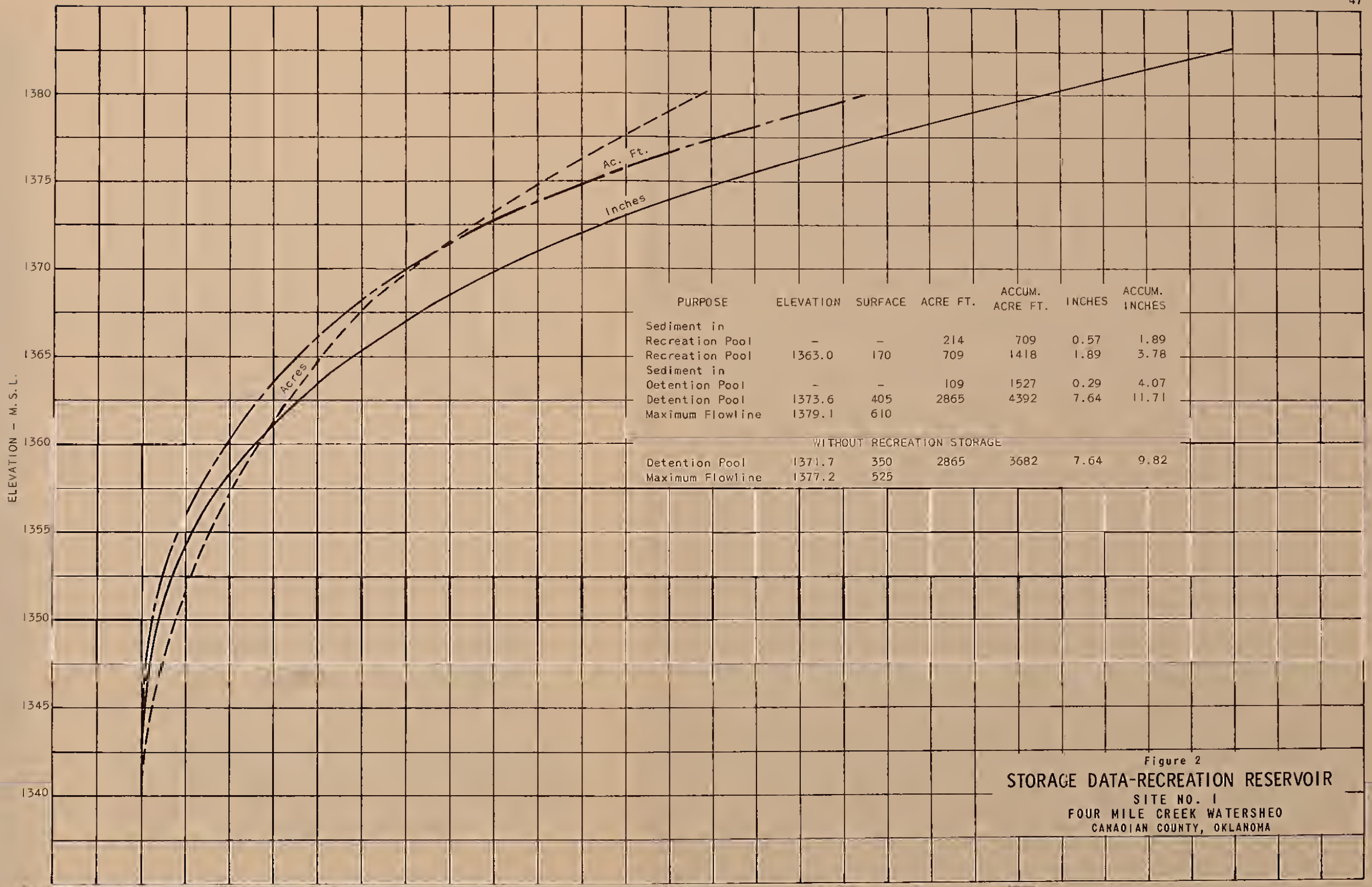


Figure 1

SECTION OF A TYPICAL MULTIPLE-PURPOSE STRUCTURE
WITH RECREATION STORAGE

U. S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE

2-64 4-L-18621



PURPOSE	ELEVATION	SURFACE	ACRE FT.	ACCUM. ACRE FT.	INCHES	ACCUM. INCHES
Sediment in Recreation Pool	–	–	214	709	0.57	1.89
Recreation Pool	1363.0	170	709	1418	1.89	3.78
Sediment in Oetention Pool	–	–	109	1527	0.29	4.07
Detention Pool	1373.6	405	2865	4392	7.64	11.71
Maximum Flowline	1379.1	610				
WITHOUT RECREATION STORAGE						
Detention Pool	1371.7	350	2865	3682	7.64	9.82
Maximum Flowline	1377.2	525				

Figure 2

STORAGE DATA-RECREATION RESERVOIR

SITE NO. 1

FOUR MILE CREEK WATERSHEO

CANAOIAN COUNTY, OKLANOMA

U. S. OEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE, Stillwater, Oklahoma

Rev. 2-64 4-R-18331

R. 7 W.

T. 12 N.

0 1 2 MILES

APPROX. SCALE

Figure 3

URBAN BENEFIT AREA
EL RENO, OKLAHOMA

FOUR MILE CREEK WATERSHED

CANADIAN COUNTY, OKLAHOMA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

STILLWATER, OKLAHOMA

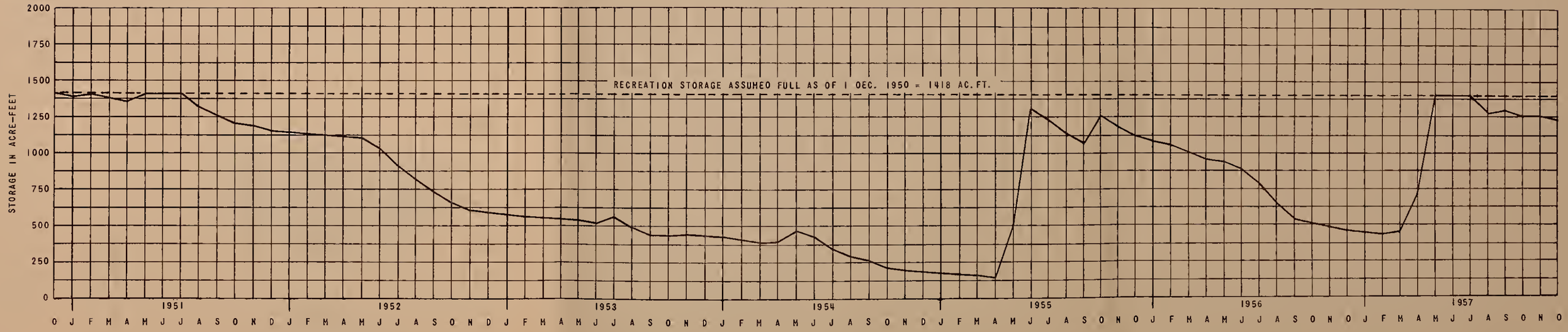
Revised 2-64

10-63 4-R-18368

Figure 4

RESERVOIR OPERATION STUDY
EFFECT OF EVAPORATION ON RECREATION STORAGE

SITE NO. 1
FOUR MILE CREEK WATERSHED
CANADIAN COUNTY, OKLAHOMA



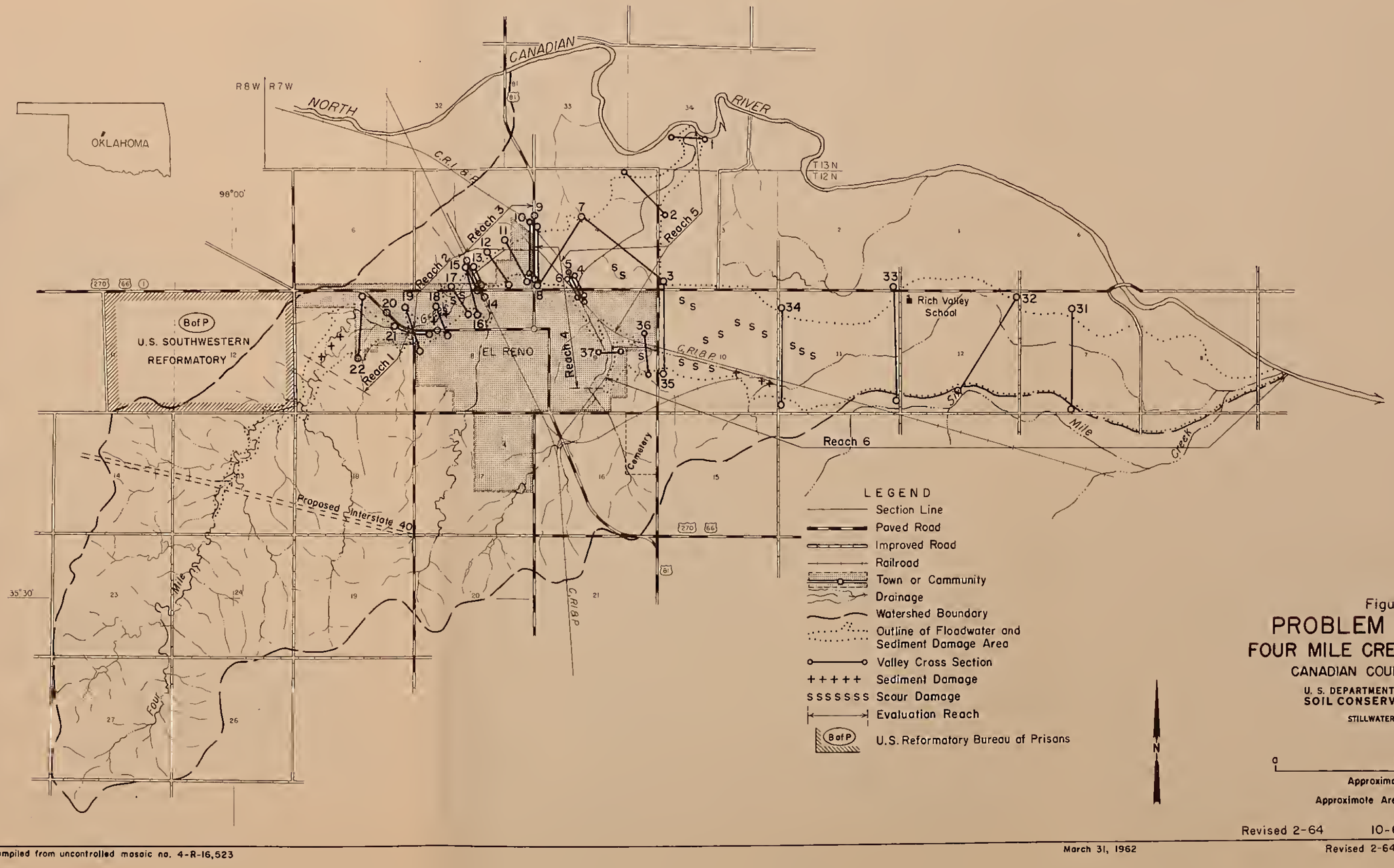


Figure 5

PROBLEM LOCATION

FOUR MILE CREEK WATERSHED

CANADIAN COUNTY, OKLAHOMA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
STILLWATER, OKLAHOMA

Base compiled from uncontrolled mosaic no. 4-R-16,523

March 31, 1962

Revised 2-64 10-63 4-R-18,354

Revised 2-64 4-R-16,524

SITE NO. 1

POPULATION DENSITY AND VICINITY MAP
(1960 Census)

R. 8 W. R. 7 W.

Camping Area

Emergency Spillway

Picnicking Area

Play Ground Area

Picnicking Area

B of P

Detention Pool
Elev. 1373.6

Beach Area

Recreational Pool
Elev. 1363.0

This area blocked by highwall fill

Spillway Crest Elev. Plus 2 Feet

Temporary Pool
Elev. 1363.1 formed
by highway box culvert.

North Right of Way Boundary of
Proposed Interstate Highway 40

11 12
14 13

12 7
13 18

T. 12 N.
14 13
23 24
13 18
24 19

LEGEND

- Recreational Area Boundary
- B of P — Federal Land Bureau of Prisons
- Improved Road
- Semi-Improved Road
- Public Road
- Boat Ramp
- Boat Dock
- Fishing Pier
- Shelter
- Latrine (Flush Type)
- Latrine (Pit Type)
- Parking Area

N

0 400 800 1200 1600
SCALE IN FEET

Figure 6
RECREATIONAL DEVELOPMENT
FOUR MILE CREEK WATERSHED
SITE No 1
CANADIAN COUNTY, OKLAHOMA
U S DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
STILLWATER OKLAHOMA

Revised 4-64 Revised 2-64 10-63 4-R-18340

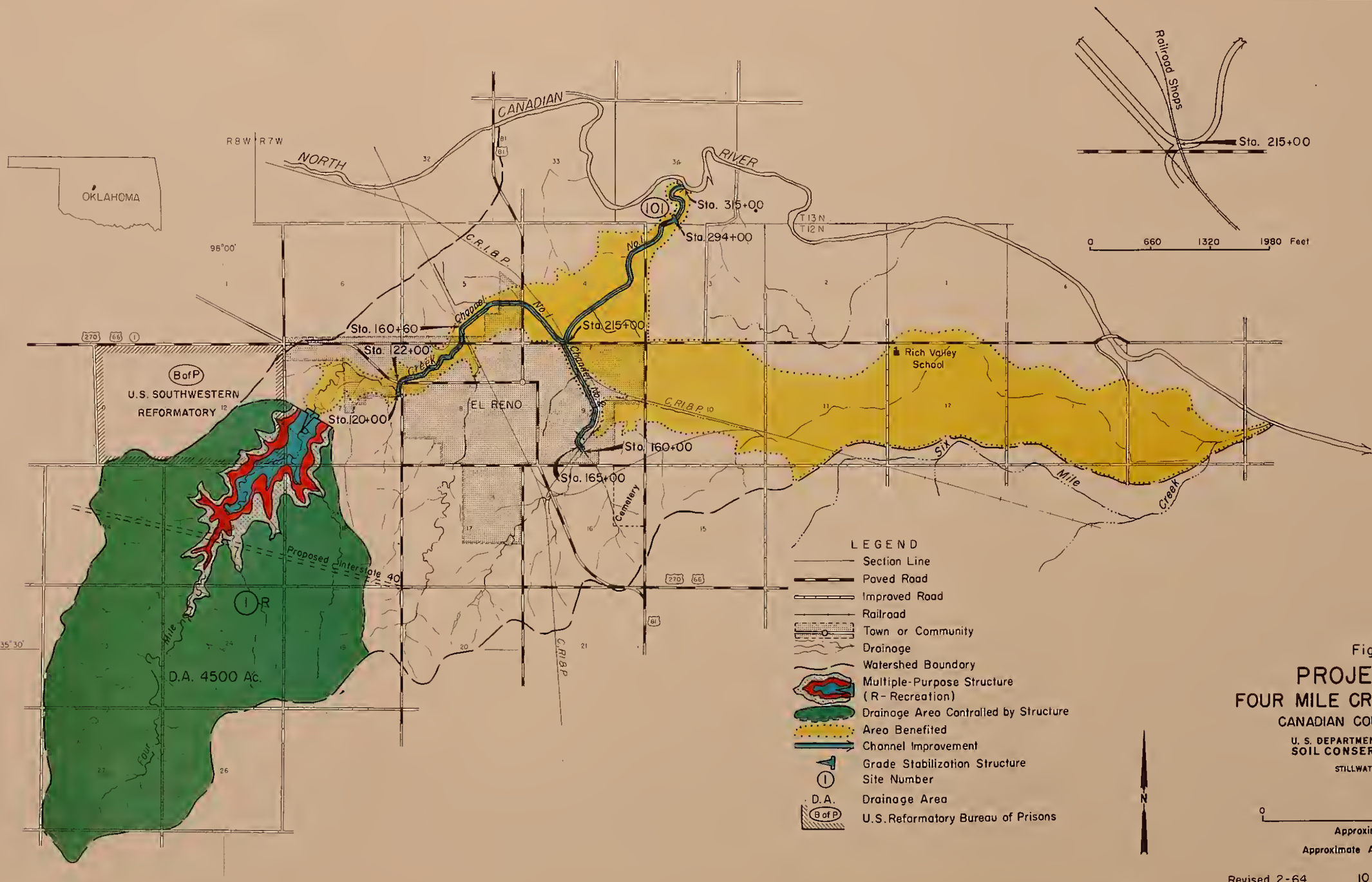


Figure 7

PROJECT MAP
FOUR MILE CREEK WATERSHED
CANADIAN COUNTY, OKLAHOMA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
STILLWATER, OKLAHOMA

Revised 2-64 10-63 4-R-18,355

Base compiled from uncontrolled mosaic no. 4-R-16,523

March 31, 1962 Revised 2-64 4-R-16,524